CMI WORKPLAN

PAD980550594

SUNOCO INC (R&M) MARCUS HOOK REFINERY

TSD

CORRECTIVE ACTION/FACILITY REMEDIATION

M5

Box
8 of 8

Sun Company, Inc. (R&M)

PHASE I
STABILIZATION MEASURES
WORK PLAN

MIDDLE CREEK ABATEMENT PROJECT
MARCUS HOOK, PENNSYLVANIA

March 1993

VOLUME 1 - TEXT

Brown & Root Braun
and
Halliburton NUS
CORPORATION

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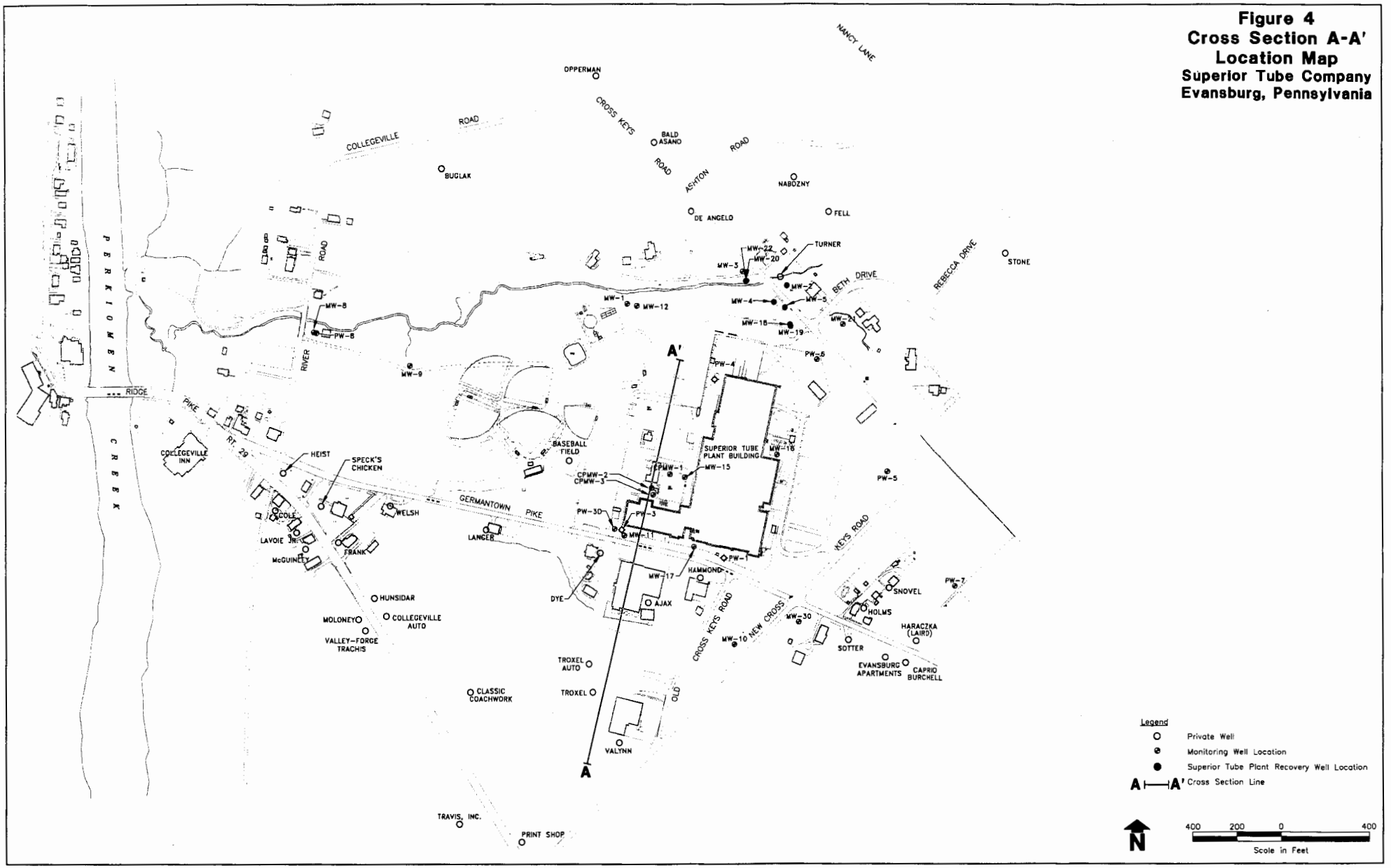
Superior Tube Company
Evansburg, Pennsylvania



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1.0 INTRODUCTION

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1.0 INTRODUCTION

Sun Company Inc. (R&M), hereinafter referred to as Sun, Marcus Hook petroleum refinery, hereby submits a Phase I Stabilization Measures Work Plan (Work Plan) for Solid Waste Management Unit #96, commonly referred to as the Middle Creek Surface Drainage System (Conveyance) located at Sun's Marcus Hook, Pennsylvania, petroleum refinery. The Marcus Hook refinery is located on the Pennsylvania/Delaware border, along the Delaware River.

This Work Plan is submitted in response to the requirements of the Corrective Action Permit (CAP) [issued to] Sun by the United States Environmental Protection Agency (EPA), Region III (Permit No. PAD 980 550 594), relating to stabilization of the Conveyance. The Work Plan consists of the following volumes:

- Volume 1: Text
- Volume 2: Drawings
- Volume 3: Appendices

1.1 BACKGROUND

Hazardous Waste Permit Number PAD 980 550 594 was issued to Sun by the Commonwealth of Pennsylvania Department of Environmental Resources (PADER) on July 6, 1990. In response to the Toxicity Characteristics Rule (TC Rule; 55 FR 11798, March 29, 1990), when the Conveyance became subject to hazardous waste regulations, Sun submitted a Class I permit modification application to EPA on September 24, 1990, to include the Conveyance in its existing permit. On September 25, 1990, the TC Rule became effective. The Conveyance thereafter became regulated as an interim status hazardous waste surface impoundment. Prior to the effective date of the TC Rule, in August of 1990, EPA performed a RCRA Facility Assessment (RFA) of the Marcus Hook refinery.

In response to the Petroleum Refinery Primary Sludge and Secondary Oil/Water/Solids Separation Sludge Listings (Primary Sludge Rule; 55 FR 46354, November 2, 1990), Sun submitted a second Class I permit modification to EPA on March 22, 1991. A combined Class III permit modification addressing both the TC Rule and the Primary Sludge Rule was then submitted to EPA on March 26, 1991. The Primary Sludge Rule became effective on May 2, 1991.

The Class III permit modification included a tentative closure plan for the Conveyance. This plan was modified by a Class I permit modification, which was submitted to EPA on February 7, 1992. This submittal was prepared to (1) specify an integrated approach to landfill closure of the conveyance and corrective action; and (2) acquaint EPA with the design basis and technical approach to be applied in achieving stabilization of the Conveyance.

1.2 FACILITY LOCATION

The Marcus Hook refinery is located on the Pennsylvania/Delaware border along the western bank of the Delaware River. The refinery is approximately 10 miles southwest of Philadelphia, Pennsylvania, at latitude 39° 49' 05" North and longitude 75° 24' 41" West. A site map is included as Figure 1-1.

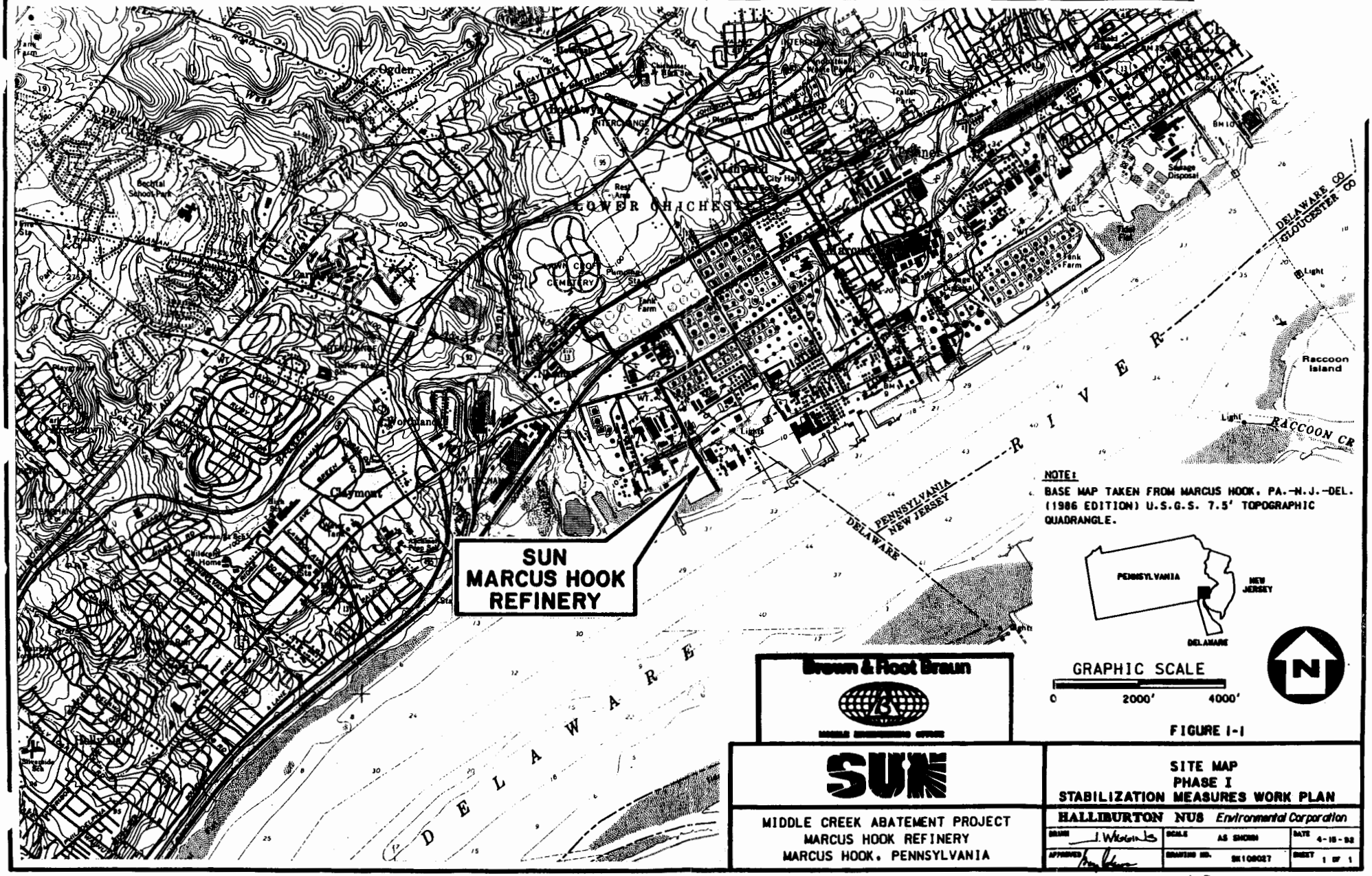
1.3 UNIT DESCRIPTION

As illustrated in Figure 1-2, the existing Conveyance is composed of an earthen channel, approximately 1.5 miles in length. The north/south leg of the channel begins at a V-notch weir, in the northeastern section of the refinery, near the intersection of Post Road and Hewes Avenue. The Conveyance stretches southward from that point to the intersection of Hewes Avenue and Middle Creek Road. The east/west leg of the Conveyance begins in the southeastern section of the refinery and extends westward beyond Blueball Avenue to a concrete dam.

The waste in the existing Conveyance consists of combined wastewater and stormwater which includes primary sludge solids from the upstream units and the T-101 surge tank and sedimentation deposits. The Conveyance transports a daily average of five million gallons of combined process wastewater and storm water runoff from the refinery to an onsite treatment facility, which discharges to a publicly owned treatment works (POTW) facility at the Delaware County Regional Authority (DELCORA).

1.4 OBJECTIVES

The existing Conveyance is being stabilized as a hazardous waste surface impoundment consistent with closure as a landfill. The objectives of the associated design and construction activities are to meet the stabilization/remediation requirements of the CAP and the related closure requirements. In particular the objectives enable compliance with capping requirements regarding control of run-on and runoff from stormwater.



NOTE:
BASE MAP TAKEN FROM MARCUS HOOK, PA.-N.J.-DEL. (1986 EDITION) U.S.G.S. 7.5' TOPOGRAPHIC QUADRANGLE.

GRAPHIC SCALE
0 2000' 4000'

N

FIGURE 1-1

Brown & Root Braun

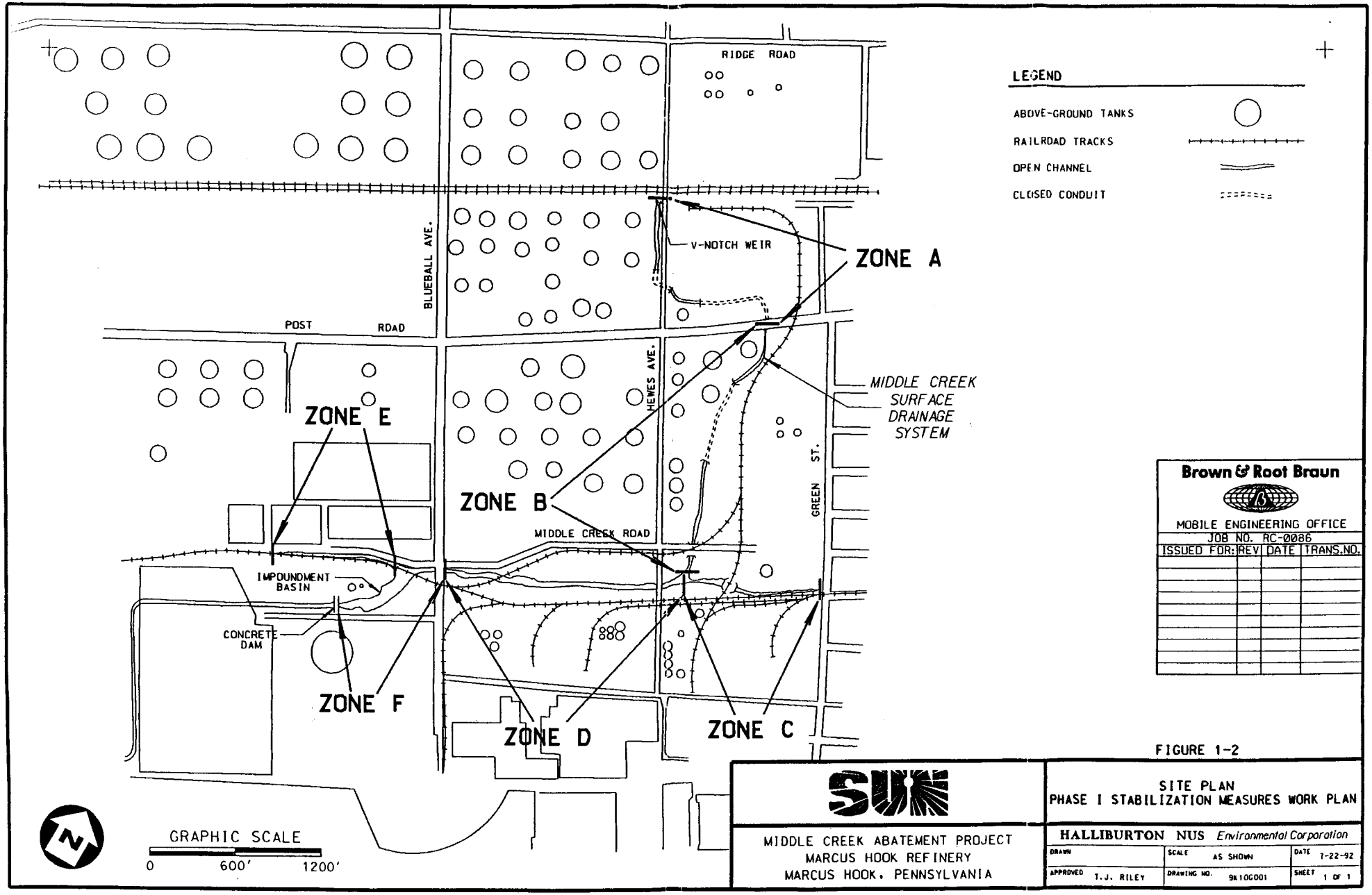
SUN

MIDDLE CREEK ABATEMENT PROJECT
MARCUS HOOK REFINERY
MARCUS HOOK, PENNSYLVANIA

SITE MAP
PHASE I
STABILIZATION MEASURES WORK PLAN

HALLIBURTON NUS Environmental Corporation

DRAWN J. Wilson	SCALE AS SHOWN	DATE 4-18-92
APPROVED	DRAWING NO. SK108037	SHEET 1 OF 1



Brown & Root Braun

MOBILE ENGINEERING OFFICE

JOB NO. RC-0086

ISSUED FOR:	REV	DATE	TRANS.NO.

FIGURE 1-2

SUN

MIDDLE CREEK ABATEMENT PROJECT
MARCUS HOOK REFINERY
MARCUS HOOK, PENNSYLVANIA

SITE PLAN
PHASE I STABILIZATION MEASURES WORK PLAN

HALLIBURTON NUS *Environmental Corporation*

DRAWN		SCALE AS SHOWN	DATE 7-22-92
APPROVED T.J. RILEY		DRAWING NO. 9R10G001	SHEET 1 OF 1

Stormwater will be conveyed along the cap to prevent accumulation of run-on on the cap. A new process wastewater system will be superimposed on portions of the existing unit. This stabilization/remediation and construction project is known as the Middle Creek Abatement Project (MCAP). The major objectives of this project are as follows:

- Landfill closure of the existing Conveyance.
- Construct a cap for the existing Conveyance that will meet the design criteria of 40 CFR 265.228 (a)(2)(iii) (A), (B), (C), (D), and (E).
- Stabilize all soft sediment (sediment) and/or underlying sediment as required under 40 CFR 265.228 (a)(2)(i) and (ii).
- Enclose all dry weather flow.
- Segregate all process wastewater.

A schedule showing major stabilization milestones is provided in Table 1-1.

1.4.1 Zones

Construction activities in the Conveyance will be conducted in six zones, as illustrated on Figure 1-2. Zone A extends approximately 1,350 feet north and west of the point where the Conveyance discharges under Post Road. Zone B is located between Post Road and Middle Creek Road. Zone C is approximately 1,000 feet long and extends eastward from the confluence of the north/south segment and continues to Green Street. Zone D is approximately 1,720 feet long. Zone E is the impoundment basin backwater, or West Ditch, which is approximately 1,140 feet long. Zone F includes the impoundment, or pH Basin.

The zone concept provides a systematic approach to stabilization while maintaining refinery operations during construction. This approach will accommodate the continued transport and treatment of process wastewater and storm water while the new system is being completed. Upon completion of construction within a zone, process wastewater and storm water will be conveyed in the new system.

TABLE 1-1
MIDDLE CREEK CONVEYANCE
STABILIZATION MILESTONES

	EVENT	BEGIN DATE	END DATE
1	Prepare pH Basin for Sediment Consolidation	01-Apr-93	21-May-93
2	Excavate Sediments from Existing Conveyance.	15-Apr-93	01-Oct-93
3	Stabilization of Conveyance (Zones A,B,C&D)	06-Jun-93	11-Feb-94
4	Existing RCRA Impoundment No Longer Accepts Hazardous Waste		29-Mar-94
5	MCAP Treatment System Construction	01-May-93	29-Mar-94
6	Stabilization of Zone E (pH Basin) and Zone F	28-Apr-94	30-Mar-95
7	Stabilization Certification		30-Jul-95
8	Post-Stabilization Period Begins	30-Mar-95	

1.5 ZONE-SPECIFIC STABILIZATION METHODOLOGY

The environmental conditions of the existing Conveyance at the refinery vary over its length. In some locations, equipment access to the existing Conveyance is virtually impossible. The stabilization method used therefore must be adjusted for the conditions encountered in each zone and sub-zone of the Conveyance. Solidification will be provided to the extent necessary to provide stability, strength, and support for the new system structure as well as the RCRA cap. The following subsections provide zone-specific methodologies for the proposed closure approach. See Figure 1-2 for the general locations of the zones subsequently described. The following provides a general overview of the stabilization methodology to be used in each zone. A detailed description is included in Section 4.0 (Technical Approach).

1.5.1 Zone A

Stabilization of the existing Conveyance within Zone A, north of Post Road, will include consolidation of soft sediment into other areas of the Conveyance, followed by in-situ solidification. In-situ solidification will be used to stabilize materials for structural support of the cap, except where obstructions limit equipment access to the Conveyance. In these areas, materials will be moved into other areas where stabilization will then be conducted. The in-situ process will include mixing of stabilizing agents such as cement or fly ash with residual sediments. Water will be added, as required, for cement hydration and mixing. Process wastewater and storm water will be diverted during stabilization activities.

In areas obstructed by existing structures, pipe supports, and pipe crossings, sediment material will be hand excavated, hydroblasted, or vacuumed. The removed material will be transported downstream. The excavated areas will then be backfilled with select material as specified in this document.

The final graded ditch will be lined with a low-permeability cap. All influent process and storm pipelines currently discharging to the Conveyance will be either removed, or plugged and abandoned. The final drainageway of Zone A will transport only storm water runoff generated in the Zone A watershed. The new drainageway will feed into the headwaters of the new process wastewater system located just south of Post Road in Zone B.

1.5.2 Zones B and D

The new wastewater conveyance system will be superimposed over the existing Conveyance at the majority of locations throughout Zones B and D. Current design of the new channel in these areas of superposition calls for installation of two parallel sheet piling walls within the existing Conveyance drainageway. These walls will define the lateral extent of the new concrete channel. Movement of materials within the sheet piling walls, as needed to construct the new channel, will be accomplished using mechanical excavation or a dredge to attain proper grades and cross sections for the installation of the new channel. Sediment materials will either be conveyed to the pH Basin or be used as backfill. Stabilization techniques using cement, fly ash, or locally available clean fill will be used, as required, to provide structural support for the new channel and cap.

For areas in Zone B where the new system will not superimpose the existing Conveyance, the sediment in the existing Conveyance will be removed and replaced with select fill or will be stabilized in situ to achieve structural support for the cap. After these activities are completed, this portion of the Conveyance will be backfilled to grade with locally available fill or excess cut material, capped with a low-permeability material and sloped to drain. The fill may be obtained from other construction excavation areas where the new system will not be superimposed over the existing Conveyance.

1.5.3 Zone C

Stabilization of Zone C will encompass three different construction scenarios, as itemized below.

1. The western portion of Zone C, which extends from the confluence of Walkers Run and Middle Creek (the confluence) and continues approximately 100 feet due east, will be superimposed by the new system. Stabilization procedures for this area will be similar to those in Zone D.

2. The midsection of Zone C is an underground culvert, which begins at the eastern edge of the new system and extends eastward approximately 100 feet. This midsection will not be overlain by the new system. In this area the culvert will be plugged, abandoned or removed.

3. The area east of the culvert extends approximately 500 feet and terminates at the edge of the refinery at Green Street. This area consists of a shallow, man-made ditch that transports storm-water sheet flow from the adjacent railroad tracks westward toward the existing Conveyance. Stabilization efforts for this area will include excavation, removal and/or solidification of ditch material. A concrete chase will be installed with an approximate 0.5-percent grade, which will allow storm water to flow toward catch basins placed at 100-foot intervals along the ditch. These catch basins will discharge to an existing 20-inch carbon steel pipe buried beneath the ditch. This pipe will be extended to discharge into the new process wastewater pipeline.

1.5.4 Zones E and F

Activities related to Zones E (the drainage ditch extending westward from the pH Basin at Blueball Avenue, hereinafter referred to as the West Ditch) and F (the pH Basin) include the following:

1. Dewatering of the pH Basin and subsequent discharge to the existing wastewater treatment system.

2. In-situ stabilization of the existing sediments within the pH Basin as required to maintain structural stability of subsequent backfill.

3. Perimeter grading, creation of berms, or installation of sheet pile walls to control run-on/runoff of the impounded waters and to contain the consolidated materials within the boundaries of the pH Basin. A pipe system will be installed to maintain flow from upstream of the Conveyance discharge to the treatment system influent structure.

4. Placement of excess excavated materials from upstream and other locations associated with stabilization/closure locations to the extent that such placement is compatible with continued operation of the existing treatment system.

These activities will be implemented during excavation for the new channel. Materials will be moved to the pH Basin through transportation methods including pumping of dredged material and/or truck transportation. At the end of the Conveyance replacement project, the pH Basin and the West Ditch will be further stabilized and a low-permeability cap installed.

2.0 ENVIRONMENTAL SETTING

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2.0 ENVIRONMENTAL SETTING

2.1 GEOLOGY

2.1.1 General Stratigraphic Setting

Published geologic information indicates that the Marcus Hook refinery is underlain by pre-Cambrian metamorphic and igneous rock. Generally, older metamorphic mica schist and gneiss was intruded by igneous rock comprised chiefly of gabbro. The remnants of the mica schist and gneiss are highly decomposed and generally overlie the gabbroic intrusion. Overlying the decomposed rock are unconsolidated deposits of the Trenton Gravel, a Pleistocene age, coastal plain sedimentary sequence. This formation consists mainly of sands and gravels, and occasional clayey and silty beds. Partly decayed vegetation and peat bogs are also occasionally found within this unit. The Trenton Gravel is correlatable to the Cape May Formation, an older stratigraphic designation.

Recent subsurface investigations indicate that near-surface materials underlying the Marcus Hook refinery include gravelly to clayey fill material and natural, unconsolidated, gravelly sands to clayey silts with some highly organic horizons. The natural sediments, interpreted to be part of the Trenton Gravel, are underlain by weathered mica schist and gneiss, and fresh gabbroic bedrock at depths of approximately 5 to 50 feet. The bedrock surface generally dips southeastward toward the Delaware River.

2.1.2 Soil Survey

The following stratigraphic discussion is based primarily on information obtained from drilling 48 soil borings during a geotechnical investigation conducted in March 1992 (Geotechnical Investigation of Marcus Hook Refinery, Brown & Root Braun). Boring logs from borings along the Conveyance are included in Appendix 2.1. Locations of the borings are shown in Drawing 1-0-5A/25050A (Volume 2). Locations of the sediment probes are shown in Drawing 1-0-5A/25051A (Volume 2). Analytical results from the sediment probes are discussed in Section 3.0. Geotechnical laboratory data from both investigations are included in Appendix 2.1 (Volume 3).

Outside the Conveyance at the Marcus Hook refinery, the subsurface sediments were divided into seven stratigraphic units (F, 1A, 1B, 1C, 2, 3, and 4), based on engineering and lithologic properties. The units were differentiated according to the Unified Soil Classification System (USCS), when applicable. These units, with USCS classifications in parentheses, are (with generally increasing depth):

F - Heterogeneous, loose to dense, fill material

1A - Stiff silts/clays (ML or CL)

1B - Very soft, recent deposits of organic silts/clays (OH or OL)

2 - Very dense sands and gravels (SW/GW/SM/GM)

1C - Firm, older deposits of organic silts/clays (OL)

3 - Dense, stiff, decomposed mica schist and gneiss

4 - Fresh, hard gabbro bedrock

Cross-sectional views of the site stratigraphy are presented in Drawing 1-0-5A/25052A (Volume 2).

Five of these stratigraphic units, which constitute the primary lithologies encountered at the site, are as follows.

Fill material (F) consists of brown to black to grey sand, gravel, silt, and clay, with brick fragments, rock fragments, tar, cinders, and wood. This material was encountered in a majority of the borings adjacent to the Conveyance. Results of a standard penetration test (SPT) conducted in accordance with American Society for Testing and Materials (ASTM) 1586 indicate that the density of this stratum is highly variable.

The "stiff" silt/clay unit (1A) consists of brown to grey silt with varying amounts of clay, and lesser amounts of sand and gravel. The grain size curves are presented in Appendix 2.1 (Volume 3). This horizon was encountered in most of the borings with SPT results, a fact which indicates that material consistency ranged from firm to very stiff. Although this unit was widespread, it was encountered at various depths in the borings and does not appear to be laterally continuous. Additional laboratory results indicate the following:

- Liquid Limits ranged from 28 to 32 percent.
- Plasticity Index ranged from 2 to 7 percent.
- Overconsolidation ranged from 1.5 to 2.0 tons per square foot (tsf).
- Compression Index was 0.11 to 0.20.
- Cohesion ranged from 1000 to 3000 pounds per square foot (psf).
- Angle of Internal Friction was 22 degrees.

The "recent" organic silts and clay unit (1B) consists of grey to black to brown silt and clay with varying amounts of organic material. The grain-size curves are presented in Appendix 2-1 (Volume 3). Organic contents (based on loss of ignition tests) ranged from 3 to 52 percent, with most between 20 to 30 percent. SPT results indicate that this layer is very soft to firm. This horizon was encountered primarily in the southern vicinity of the Conveyance. Additional laboratory results indicate the following:

- Liquid Limits ranged from 2 to 178 percent.
- Plasticity Index ranged from 5 to 88 percent.
- The soils are normally consolidated.
- Void Ratios ranged from 1.7 to 4.6.
- Compression Index was 1.0.
- Cohesion ranged from 400 to 600 psf.

The "very dense" sand and gravel unit (stratigraphic unit 2) consists of brown to orange-brown sand and gravel, with trace to some silt and clay, and occasional cobbles. The grain size curves are presented in Appendix 2.1 (Volume 3). This horizon was encountered in most of the borings, with SPT results showing the material as dense to very dense, with medium density silt lenses. Laboratory data show the material to be generally well graded, with an angle of internal friction of 40 to 47 degrees.

The "firm" older organic silts and clay unit (1C) is dark brown to black with varying amounts of organic material. Although this horizon was laterally extensive south of the Conveyance, it was only encountered in boring B-37-17. Organic contents (from loss of ignition) ranged from 32 to 53 percent. The soils are slightly overconsolidated, with void ratios of 0.6 to 1.6. SPT results indicate that this horizon is firm. This layer typically underlies the sand and gravel horizon at the refinery.

2.1.3 Conveyance Sediments

An investigation of the material lying within the Conveyance was conducted through sediment probing and sampling. The methodology and contaminant chemistry results are discussed in detail in Section 3.0. Within the Conveyance, surface sediments consist of primarily silts, sands, and gravels. These sediments

have a soft to sticky consistency, and are termed "soft sediment." The sediment is laden with a black, oily, colloidal material and ranges in thickness from 0.67 to 13.5 feet.

Beneath the sediment, a green to grayish black, silty clay strata, termed "underlying sediment," is present in most areas (corresponding to the silt/clay horizon or fill material discussed in Subsection 2.1.2). Beneath this transitional zone underlying sediment is indistinguishable from sediment outside the Conveyance.

In addition to visual inspection and depth measurements made in the field, soft sediment in the Conveyance was examined for geotechnical properties. Six soft sediment samples were tested in accordance with ASTM standards to determine in-situ moisture content (ASTM D698), disturbed unit weight (ASTM 2216 and D2974), moisture density relationships (ASTM D698), Atterberg limits (ASTM D4318), and physical constituents. Table 2-1 presents a summary of those test results. Three sample pairs were analyzed: one pair each from Zones B, D, and F. Each pair consisted of one deep sample and one shallow sample.

Based on the laboratory data, the soft sediments consist of a mixture of gravel, sand, silt, clay, and oil and grease, in varying proportions. The grain size curves for soft sediment are shown in Appendix 2.1 (Volume 3, Plates 4 and 5). In general, the sediments are clayey sands and are classified as SC and SM soils in accordance with the USCS. The sediments contain 6 to 14 percent oil and grease, by dry weight, and are moderately plastic. Liquid limits varied from 31 to 51 percent.

The in-situ moisture contents of the soft sediment in the Conveyance ranged from 47 percent to 58 percent, well above their liquid limits. The disturbed wet unit weight of the samples varied from 91 to 106 pounds per cubic foot. The wet condition of the soft sediment prohibited the collection of undisturbed samples. However, the disturbed unit weights are believed to be comparable to the in-situ unit weights.

Moisture density relationships of the soft sediments were determined at four moisture contents for each sample using the standard Proctor method (ASTM D698). Moisture contents were selected to encompass the moisture range expected during construction, which is anticipated to be on the "wet side" of the optimum moisture content. The moisture density curves and zero air void curve for the six samples are provided in Appendix 2.1 (Volume 3, Figures 3-1 to 3-6).

TABLE 2-1
SUMMARY OF SELECTED ENGINEERING PROPERTIES
OF SOFT SEDIMENT SAMPLES

ENGINEERING PARAMETER	SAMPLE IDENTIFICATION					
	D1S	D1D	B4S	B4D	F1S	F2D
Soil Classification (a)	SC	SC	SC	SM	GM	CH
In-Situ Moisture Content, %	47.3	57.8	52	40.9	56.7	56.1
Dry Unit Weight, pcf (b)	63.8	57.9	65.5	75.4	58.9	60.9
Hydrocarbons,% (c)	13.9	13.9	5.9	6.2	13.2	7.2
Soil, % (d)	86.1	86.1	94.1	93.8	86.8	92.8
Gravel, %	5	3	12	4	32	2
Sand, %	53	49	50	66	30	46
Silt and Clay, %	42	48	38	30	38	52
Liquid Limit, %	31	40	34	32	45	51
Plasticity Index	15	19	11	8	12	16

(a) Unified Soil Classification System (ASTM D2487);
SC=Clayey Sands; SM=Silty Sands; GM=Silty Gravels;
CH=High Plasticity Inorganic Clays
(b) Dry unit weight of disturbed sample, pounds per cubic foot (pcf)
(c) Percentage of Solids: Soil plus Hydrocarbons = 100%
(d) Percentage of Soil: Gravel + Sand + Silt + Clay = 100%

2.1.4 Bedrock Description

Pre-Cambrian age metamorphic (mica schist and gneiss) and igneous (gabbro) bedrock underlies the fill material and unconsolidated sediments in the refinery area at depths of 5 to 50 feet. The bedrock surface has an irregular topography but generally slopes toward the Delaware River. The shallowest bedrock is encountered at the north (upstream) end of the existing Conveyance, north of Post Road.

2.2 GROUNDWATER HYDROGEOLOGY

2.2.1 Groundwater Flow Pattern

Regional groundwater flow mimics surface topography and is south toward the Delaware River. Within the refinery, groundwater flow is also toward the south, with a component of flow southeastward toward the north-south extension of the Conveyance, as shown in Drawing 1-0-5A/25053A (Volume 2).

The shallow groundwater system at the Marcus Hook refinery lies at depths of approximately 3 to 10 feet below ground surface within the fill material and Trenton Gravel. The underlying gabbroic bedrock has extremely low primary porosity and little development of fracturing. Therefore, there are no underlying aquifers hydraulically connected to the uppermost aquifer. Data from a study conducted to determine the influence of tidal fluctuations in the Delaware River show that there is no influence on groundwater levels.

2.2.2 Hydrogeologic Properties of Stratigraphic Units

This subsection presents a description of the hydrogeologic properties of stratigraphic units of soils at the Marcus Hook refinery, including hydraulic conductivity, hydraulic interconnections, and attenuation capacities of soils.

Based on existing data, the shallow groundwater system is considered to be unconfined, although some confining conditions may be present locally where finer grained silts and clays overlie sand and gravel.

Slug tests and a pump test were conducted at the refinery during a previous investigation summarized in the Class III Permit Modification application submitted by Sun to the EPA on March 26, 1991. Slug tests from four wells showed hydraulic conductivity in the shallow groundwater system ranging from 6.95×10^{-3} to 4.59×10^{-4} cm/sec.

The pump test results from a pumping well and one observation well positioned approximately 75 feet south of the confluence are shown in Table 2-2. Depending on the reduction method, the transmissivity of the shallow groundwater system was calculated to be approximately 1400 to 1900 gallons per day per foot (gpd/ft) with a storage coefficient of 2.21×10^{-4} to 3.17×10^{-4}. The calculated storage coefficient value may be lower than the actual storage coefficient.

The short-term pump test (24 hours) may not have recorded the entire water volume that would ultimately be produced from gravity drainage within the cone of depression. This value may be indicative of transient, non-equilibrium conditions. Therefore it may not be accurate for long-term pumping calculations.

2.3 SURFACE WATER HYDROLOGY

The Conveyance serves as a drainageway conveying process wastewater and stormwater from refinery operations and includes an impoundment basin. Water in the basin is pretreated and then discharged to an offsite industrial wastewater treatment plant operated by the Delaware County Regional Authority (DELCORA).

The average daily discharge of dry-weather flow from the Conveyance is 5.08 mgd (3500 gpm). The average flow rate of stormwater through the Conveyance is 1.22 mgd. Average rainfall in the Marcus Hook area is 42 inches per year.

2.4 CLIMATE

The Sun Marcus Hook Refinery is located in an area subject to climate moderation due to the influence of the Appalachian Mountains to the west and the Atlantic Ocean to the east. Data from the nearest, most representative National Weather Service (NWS) reporting station was used to summarize climatic conditions for the Marcus Hook location. The closest NWS reporting station is located at the Philadelphia International Airport, which is approximately 10 miles to the northeast. Both Marcus Hook and the airport are located on the northern bank of the Delaware River at about the same topographic elevation.

Periods of very high or very low temperatures seldom last for more than three or four days at a time. Temperatures below zero or above 100 degrees are rare. On occasion, the area becomes engulfed with maritime air during the summer months. High humidity adds to the discomfort of seasonably warm temperatures. A summary of mean monthly and annual average temperatures for the Philadelphia International Airport is provided in Table 2-3.

TABLE 2-2
RESULTS OF THE CONSTANT-DISCHARGE PUMP TEST

Test Type	Transmissivity (gpd/f)	Storage Coefficient
Theis pumping	1550	3.17 x10 E-4
Theis recovery	1910	N/A
Cooper-Jacob	1410	2.21x10 E-4

Note: gpd/f = gallons per day per foot.

TABLE 2-3

MEAN MONTHLY AND ANNUAL AVERAGE TEMPERATURES FOR THE PHILADELPHIA INTERNATIONAL AIRPORT

Month	Mean Temperature* (Degrees F)
January	31.2
Febuary	33.1
March	41.8
April	52.9
May	62.8
June	71.6
July	76.5
August	75.3
September	68.2
October	56.5
November	45.8
December	35.5
ANNUAL AVERAGE	54.3

* Mean temperatures based on the 1951 - 1980 period of record

Source: National Weather Service, Philadelphia International Airport

Precipitation is evenly distributed throughout the year, with maximum amounts occurring during the late summer months. Much of the summer rainfall is from thunderstorms, and the amounts can vary locally. The area averages about 28 thunderstorms each year, with a majority occurring from May through August. Normally measurable snowfall occurs between November and April. Snowfall amounts are often considerably larger in the northern suburbs than in the central and southern parts of the Philadelphia area. In many cases, the precipitation changes from snow to rain within the city. Individual snowstorms of 10 inches or more occur about every 5 years. A summary of mean monthly and annual total rainfall and snowfall is provided in Table 2-4.

The prevailing wind direction for the area for the summer months is from the southwest, whereas northwesterly winds prevail during the winter. The annual prevailing direction is from the west. A windrose diagram of the frequency of occurrence of wind direction for the year 1987 is shown in Figure 2-1. Highest wind speeds occur in the winter months and, as a rule, come with the advance of cold air after the passage of a deep, low-pressure system. Only rarely have hurricanes in the vicinity caused widespread damage, primarily flooding.

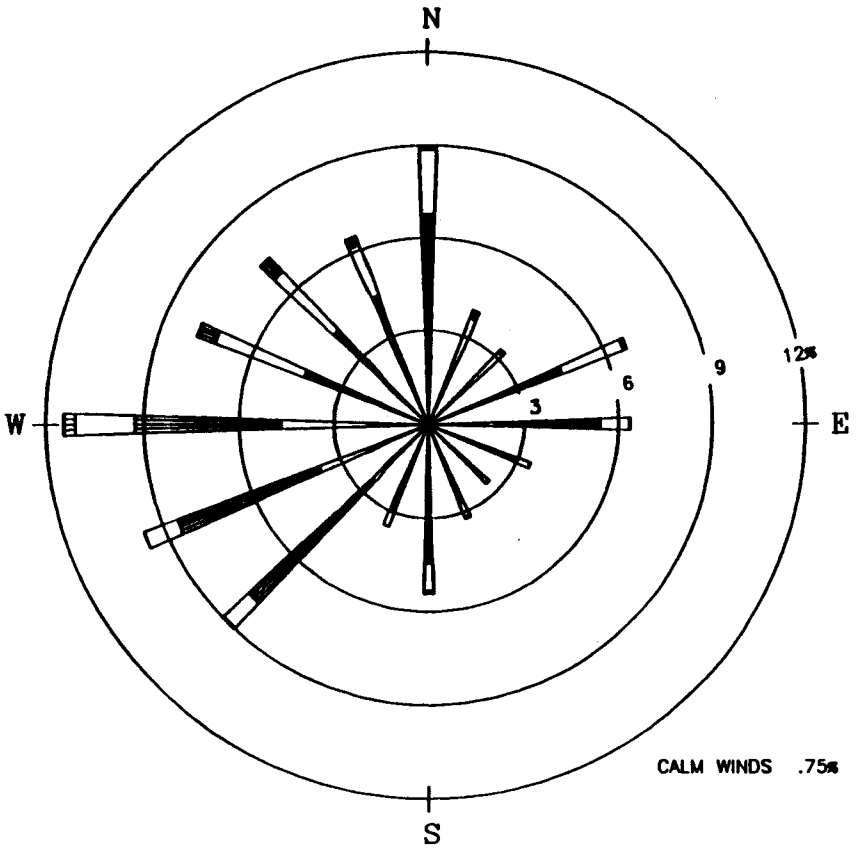
TABLE 2-4

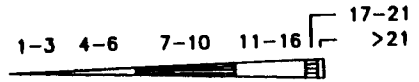
MEAN MONTHLY AND ANNUAL TOTAL RAINFALL AND SNOWFALL FOR THE PHILADELPHIA INTERNATIONAL AIRPORT*

Monthly	Mean Rainfall* (Inches)	Mean Snowfall* (Inches)
January	3.8	6.6
February	2.8	6.9
March	3.9	3.8
April	3.5	0.3
May	3.2	0
June	3.9	0
July	3.9	0
August	4.1	0
September	3.4	0
October	2.8	Trace
November	3.3	0.6
December	3.5	3.6
ANNUAL	42.1	21.8

* Means based on the 1951 - 1980 period of record.

Source: National Weather Service,
Philadelphia International Airport.





WIND SPEED CLASSES
(KNOTS)

NOTES:
DIAGRAM OF THE FREQUENCY OF OCCURRENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING.
EXAMPLE – WIND IS BLOWING FROM THE NORTH 8.9 PERCENT OF THE TIME.

WINDROSE

STATION NO. 13739
PHILADELPHIA, PA
PERIOD: 1987

FIGURE 2-1

from: CLASS III PERMIT MODIFICATION
TO PART B HAZARDOUS WASTE PERMIT
NUMBER PAD980550594
K. W. BROWN & ASSOCIATES, INC.
MARCH, 1991

SUN					WINDROSE FOR SUN MARCUS HOOK FACILITY.
PROJECT: 189090007-235				LOCATION: MARCUS HOOK, PA	
K.W. BROWN & ASSOCIATES, INC.					DATE: 3-20-91
APPR:	BDG		DRAWN BY:	SCC	SCALE: AS SHOWN
DATE:	3-21-91		DATE:	3-20-91	FIGURE: B - 3

3.0 SOURCE CHARACTERIZATION

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SECTION 3.0

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LIST OF TABLES (CONTINUED)

3.0 SOURCE CHARACTERIZATION

This section of the report provides a physical description of the Conveyance and an analysis of the chemical characteristics found in the vertical profile of the sediments within the existing Conveyance system. Information summarized includes data gathered during preparation of the Class III Permit Modification that Sun submitted to the EPA in March 1991, and results of the Initial Field Reconnaissance (IFR) (Phase I) conducted by HALLIBURTON NUS from December 4, 1991, through January 20, 1992.

IFR Phase I consisted of field measurements and sample collection and analysis to characterize sediments within the existing Conveyance. Approximately 1.5 miles of the conveyance were evaluated, beginning at the V-notched weir north of Post Road, near the 1A separator, extending downstream to the impoundment basin.

3.1 CONVEYANCE SYSTEM DESCRIPTION

3.1.1 Physical Description

The total length of the Conveyance system at the Marcus Hook refinery is approximately 1.5 miles. The Conveyance, which has been in operation since the early 1900s, consists of an earthen bed that traverses the refinery and receives process wastewater. The Conveyance includes primary sludge solids that have been conveyed, suspended in water, as the result of normal operations, such as cleaning of units that feed into the Conveyance, or received water and solids from the units, such as surge tank T-101, and from surface runoff. Tank T-101 provides surge capacity for significant precipitation events or other unusual circumstances. In some areas, pipes, piperacks, and bridges cross the Conveyance; consequently, there is limited access to the system. Within each zone of the Conveyance system, several sample locations were established during the IFR, as shown in Drawing 1-0-5A/25054A (Volume 2).

Measurements of Conveyance width, as well as sediment thickness, were taken at each location shown in Drawing 1-0-5A/25054A (Volume 2). Locations were chosen which would fulfill the objective of estimating an initial soft sediment volume. Selection was based on various parameters including the visual assessment of the variability in stream width and depth, site process knowledge, access, and distance between sampling points. As a result, Conveyance areas with significant variability in stream width and depth were sampled with greater frequency than areas which are relatively invariant. Conveyance areas that did

not exhibit characteristics that allowed selective location determinations were sampled randomly to prevent relatively long distances between sampling points. At each sample location, one to three points along a cross section of the Conveyance were probed to determine the depth of soft sediments. Locations are identified by a three-segment alphanumeric code which identifies the zone, the specific location within the zone and a cross-section identifier. In general, the location number increases consecutively, representing downstream locations within a zone. The cross section identifier represents stream cross sections from East to West or North to South, with 1 being the most easterly or northerly sample point. If only one measurement was taken at a location, the cross-section identifier would be 1. Results are summarized in Table 3-1. Table 3-2 summarizes the lithologic descriptions and HNu headspace readings for samples taken at 31 locations.

Note: The reader will notice a discrepancy between the sample locations and zone prefixes in IFR Phase I results and those represented in other sections of this document. Since the completion of IFR Phase I, the zone prefixes have been modified as follows:

IFR Phase I Zone Prefix	Current Zone Prefix
A	A
B	B
C	C
D	D
E	D
F	E
G	F

Visual observations of sediment appearance, including stratification, color, composition, and consistency, were recorded on boring log forms. Within the Conveyance, surface sediments consist primarily of silts, sands, and gravels, have a soft to sticky consistency, and are termed "soft sediment." The soft sediment is laden with a black, oily, colloidal material and ranges in thickness from 0.67 to 13.5 feet (see Table 3-1).

Beneath the soft sediment, a green to grayish black, silty clay strata is present in most areas (probably corresponding to the silt/clay horizon or fill material discussed in Subsection 2.1.1), and is termed " underlying sediment."

In several areas of Zone A, rocks and boulders were encountered beneath the soft sediment; thus deeper sampling was prevented in those areas. At a depth of approximately 2.5 feet, a highly weathered bedrock was encountered at sample locations near Hewes Avenue. At a sample location in Zone B, the soft sediment

TABLE 3-1
SUMMARY OF FIELD MEASUREMENTS:
CONVEYANCE WIDTH AND SOFT SEDIMENT THICKNESS

SAMPLE LOCATION ZONE A	CONVEYANCE WIDTH (feet)	THICKNESS OF SOFT SEDIMENT (feet)		
		East	Mid	West
A-1	12.2	--- (a)	0.67	--- (a)
A-2	6	--- (a)	3.5	--- (a)
A-3	3	--- (a)	3.5	--- (a)
A-4	5	--- (a)	(1.5) (b)	--- (a)
A-5	5	--- (a)	2.5	--- (a)
A-6	5	--- (a)	2.3	--- (a)
A-7	7	--- (a)	(2.5) (b)	--- (a)
A-8	8	--- (a)	(2)(b)	--- (a)

SAMPLE LOCATION ZONE B	CONVEYANCE WIDTH (feet)	THICKNESS OF SOFT SEDIMENT (feet)		
		East	Mid	West
B-2	10	5	4.5	4.5
B-3	8	2.5	4	2.8
B-4	18.5	2.5	8	2.5
B-5	9	1	8	1.5
B-6	13	3.5	4.5	4

SAMPLE LOCATION ZONE C	CONVEYANCE WIDTH (feet)	THICKNESS OF SOFT SEDIMENT (feet)		
		North	Mid	South
C-1	16.5	8	8	8
C-2	13.5	8	8	8

(a) All Zone A sediment thicknesses are centerline evaluations.
(b) Maximum achievable depth with manual sampling equipment.
(c) No information was developed for this portion of the Conveyance.
(d) Estimated value.

Notes:

1. Designations of zone prefixes were changed after IFR Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-1
SUMMARY OF FIELD MEASUREMENTS:
CONVEYANCE WIDTH AND SOFT SEDIMENT THICKNESS
PAGE TWO

SAMPLE LOCATION ZONE D	CONVEYANCE WIDTH (feet)	THICKNESS OF SOFT SEDIMENT (feet)		
		North	Mid	South
D-1	20	7.5	7.5	7.5
D-2	10.7	7.8	8.2	8
D-3	26	8.4	(c)	7

SAMPLE LOCATION ZONE E	CONVEYANCE WIDTH (feet)	THICKNESS OF SOFT SEDIMENT (feet)		
		North	Mid	South
E-1	18	4	4	4
E-2	27	(c)	(c)	5.5

SAMPLE LOCATION ZONE F	CONVEYANCE WIDTH (feet)	THICKNESS OF SOFT SEDIMENT (feet)		
		North	Mid	South
F-1	57	4	6	4
F-2 /F-52/F4	70 (d)	11	5	6
F-3/F-53/F-6	70 (d)	6	7.5	6.5
F-7	80 (d)	2.8	7	(c)

SAMPLE LOCATION ZONE G	CONVEYANCE WIDTH (feet)	THICKNESS OF SOFT SEDIMENT (feet)		
		East	Mid	West
G-1	23	(c)	13.5	(c)
G-2	3.5	(c)	4.5	(c)
G-3	5	(c)	4	(c)
G-4	3.5	(c)	6.7	(c)

Total length of Zone G is approximately 1,140 feet.

(a) All Zone A sediment thicknesses are centerline evaluations.
(b) Maximum achievable depth with manual sampling equipment.
(c) No information was developed for this portion of the Conveyance.
(d) Estimated value.

Notes:

1. Designations of zone prefixes were changed after IFR Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-2
SAMPLE LITHOLOGIC DESCRIPTIONS AND HEADSPACE READINGS

ZONE	SAMPLE LOCATIONS	SOFT SEDIMENT DESCRIPTION	HEADSPACE READING (ppm)	UNDERLYING SEDIMENT DESCRIPTION	HEADSPACE READING (ppm)
A	A-1	Black, silty sand		Grey, clayey sand	
	A-2	Black, oily, silty sand, trace of gravel	-6	Greenish grey, silty clay	32
	A-3	Black, oily, silty sand	180	Greenish grey, silty clay	20
	A-4	Black, oily sand, trace of gravel	8	Boulder/rocks encountered	
	A-5	Gravel and sand with oily sheen	>2000	Weathered mica schist	
	A-6	Fine to coarse gravel with oily sheen	70	Weathered mica schist	
	A-7	Brown, oily, fine- to medium-grained silt and sand	-2	Boulder/rock encountered	
	A-8	Course riprap	2	Grey, silty clay	5
B	B-2	Silty fine sand, some brick fragments, oily sheen	5	Grey, silty clay	20
	B-3	Black, oily, silty fine sand	15	Grey, silty clay	20
	B-4	Silt with trace of fine sand and clay, oily sheen	50	Brown, dense, plastic clay	
	B-5	Black, oil laden, silty sand, trace of clay	100	Dark grey, clayey silt, some brick fragments	30
	B-6	Black, silty sand trace gravel with oily sheen		Grey, clayey silt, trace of wood fragments	
C	C-1	Black, silty sand, trace gravel, with oily sheen	20	Greenish grey, silt	
	C-2	Black, oil laden, silt to sand	30	Greenish grey, silty clay, trace sand	
D	D-1	Black, oil laden, sandy silt		Grey, silt with trace to some clay, trace wood fragments	2
	D-2	Black, oil laden, fine-grained silty sand, trace gravel		Grey, silt with trace of clay	
	D-3	Black, oily, silt to coarse sand	54	Green, dense clay	5
E	E-1	Black, oily, gravelly silt	70	Green, dense clay	6
	E-2	Black, oily, silt to gravel	75	Clayey silt with high organic content	5.5

Notes:

1. Headspace readings taken with an HNu photoionization detector.
2. Headspace readings are a measure of total ionizable chemical species, principally, organics.
3. Negative readings are due to chemical interferences.
4. Blank spaces correspond to sample points where headspace analyses were not taken.
5. Designations of zone prefixes were changed after IFR Phase I. See Section 3.1.1 .
6. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-2
SAMPLE LITHOLOGIC DESRIPTIONS AND HEADSPACE READINGS
PAGE TWO

ZONE	SAMPLE LOCATIONS	SOFT SEDIMENT DESCRIPTION	HEADSPACE READING (ppm)	UNDERLYING SEDIMENT DESCRIPTION	HEADSPACE READING (ppm)
F	F-1	Black, oily, fine to coarse sand	-25	Grey to green clay, soft, high wood content	6
	F-2	Silt to coarse sand, oily sheen	110	Green to brown silty clay	5
	F-3	Black, oily, silt to sand		Green, clay, soft, some wood	
	F-4	Black, oily,silty to coarse sand loose, soft	18	Green, silty clay	6
	F-5	Black, oily, silty to coarse sand,loose	40	Grey to green clay, soft, high wood content	4
	F-6	Black, oily, coarse sand to silt	60	Green clay, soft, hydrocarbon staining on upper 0.5 feet	3
	F-7	Black, oily, silt to coarse sand		Grey silty clay with some wood fragments	
G	G-1	Black, oily, silt to coarse sand	100	Green clay, high wood content	6
	G-2	Black, oily, silt to coarse sand, some pebbles.	150	Green/grey/brown clay, dense, high wood content	7
	G-3	Black silt to coarse sand with pebbles	75	Green sandy clay with pebbles	8
	G-4	Black, oily, silt to coarse sand	140	Green clay, soft, with high wood content	4

Notes:

1. Headspace readings taken with an HNu photoionization detector.
2. Headspace readings are a measure of total ionizable chemical species, principally, organics.
3. Negative readings are due to chemical interferences.
4. Blank spaces correspond to sample points where headspace analyses were not taken.
5. Designations of zone prefixes were changed after IFR Phase I. See Section 3.1.1 .
6. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

is underlain by slag and rock, which could not be penetrated with a hand auger or a back hoe.

3.1.2 Soft Sediment Volume Estimates

A maximum of three cross-sectional points per sample location were probed to determine the transition between soft and underlying sediment. An estimate of the volume of impacted soft sediment was calculated using this cross-section data and distances taken from Drawing 1-0-5A/25054A (Volume 2). Because of the limited data and nonuniform depths to the underlying sediment contact, the volume estimates are approximations.

The cross-sectional area at a sample location was calculated by multiplying the thickness of the soft sediment column by the horizontal distance across the creek at discrete locations. The horizontal distance was determined with a tape measure, where possible. In locations where the width of the creek prohibited such measurement, distances were approximated using maps of the site.

At locations where one measurement of soft sediment thickness was recorded, the thickness of the soft sediment column corresponded to the centerline of the conveyance. A correction factor of 0.8 was used for the height to calculate cross-sectional area. At cross sections where two soft sediment thicknesses were known, an arithmetic average was used for sediment thickness. When three cross-sectional thicknesses were available, the centerline measurement was taken twice, and the average depth was based on four values rather than three.

The volume of soft sediment in each zone was calculated using the Average End Area method. The estimated volume of soft sediment in each zone was multiplied by a safety factor of 1.15. The total soft sediment volume was thus estimated as 25,745 cubic yards or 30,600 tons, based on an average wet density of 88 lbs/ cubic foot and an in-situ moisture content of 50 percent. Details of these calculations and individual zone volume estimates are summarized in Table 3-3.

3.2 SEDIMENT ANALYTICAL DATA

3.2.1 Results of Previous Investigations

In March 1991, Sun submitted a Class III Permit Modification application to the EPA that included preliminary soft sediment characterization data. Prior to submittal, four soft sediment samples were collected at locations shown in Figure 3-1 and analyzed for Toxicity Characteristic (TC) constituents and modified Skinner List constituents. Sampling and analysis of underlying sediment was not included. Analytical results are provided in Appendix 3.1.

TABLE 3-3
SOFT SEDIMENT VOLUME ESTIMATES

Cross-Section Identification (a)	Conveyance Width (Ft)	Average Soft Sediment Thickness	Depth Correction Factor	Cross-Section Area (Sq Ft)	Subzone	Average Subzone Area (b) (Sq Ft)	Length of Subzone (Ft)	Corrected Volume (c) (cubic ft.) in-place	Acre/ Feet in-place material	Weight (d) (Tons) in-place material
A1	12.2	0.67	0.80	6.54						
					A1 - A2	11.67	120	1,610	0.037	71
A2	6.0	3.50	0.80	16.80						
					A2 - A3	12.60	120	1,739	0.040	77
A3	3.0	3.50	0.80	8.40						
					A3 - A4	11.20	36	464	0.011	20
A4	5.0	3.50	0.80	14.00						
					A4 - A5	12.00	140	1,932	0.044	85
A5	5.0	2.50	0.80	10.00						
					A5 - A6	9.60	120	1,325	0.030	58
A6	5.0	2.30	0.80	9.20						
					A6 - A8	11.00	760	9,614	0.221	423
A8	8.0	2.00	0.80	12.80						
					A8 - End	12.80	50	736	0.017	32
END	8.0	2.00	0.80	12.80						
Totals/avg's Zone A	6.5	2.50	0.80	11.32		11.55	1346	17,420	0.400	766

(a) Cross-section locations from IFR report measurements. Collected at these locations. Locations shown on drawing 3.1.
(b) Subzone areas calculated using Average End Area Method. Calculations are based on field measurements of various cross sections.
(c) Corrected volume is average subzone area times length times 1.15.
(d) Average soft sediment density assumed is 88 pounds per cubic foot.
(e) Estimated Conveyance width and/or soft sediment thickness.

Notes:
1. Designations of zone prefixes were changed after IFR Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-3
SOFT SEDIMENT VOLUME ESTIMATES
PAGE TWO

Cross-Section Identification (a)	Conveyance Width (Ft)	Average Soft Sediment Thickness	Depth Correction Factor	Cross-Section Area (Sq Ft)	Subzone	Average Subzone Area (b) (Sq Ft)	Length of Subzone (Ft)	Corrected Volume (c) (cubic ft.) in-place	Acre/ Feet in-place material	Weight (d) (Tons) in-place material
N. Boundary (e)	10.0	4.6	---	46.0						
					N. - B2	46.00	180	9,522	0.219	419
B2	10.0	4.6	---	46.0						
					B2 - B3	34.20	260	10,226	0.235	450
B3	8.0	2.8	---	22.4						
					B3 - B4	60.23	760	52,637	1.208	2316
B4	18.5	5.3	---	98.1						
					B4 - B5	69.73	260	20,848	0.479	917
B5	9.0	4.6	---	41.4						
					B5 - B6	47.35	360	19,603	0.450	863
B6	13.0	4.1	---	53.3						
					B6 - S.	53.30	120	7,355	0.169	324
S. Boundary (e)	13.0	4.1	---	53.3						
Totals/avg's Zone B	11.6	4.3	---	51		44.40	1940	120,191	2.759	5288

(a) Cross-section locations from IFR report measurements. Collected at these locations. Locations shown on drawing 3.1.
(b) Subzone areas calculated using Average End Area Method. Calculations are based on field measurements of various cross sections.
(c) Corrected volume is average subzone area times length times 1.15.
(d) Average soft sediment density assumed is 88 pounds per cubic foot.
(e) Estimated Conveyance width and/or soft sediment thickness.

Notes:
1. Designations of zone prefixes were changed after IFR Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-3
SOFT SEDIMENT VOLUME ESTIMATES
PAGE THREE

Cross-Section Identification (a)	Conveyance Width (Ft)	Average Soft Sediment Thickness	Depth Correction Factor	Cross-Section Area (Sq Ft)	Subzone	Average Subzone Area (b) (Sq Ft)	Length of Subzone (Ft)	Corrected Volume (c) (cubic ft.) in-place	Acre/ Feet in-place material	Weight (d) (Tons) in-place material
E. Boundary (e)	8.0	4.0	---	32						
					E. - C1	82	800	75,440	1.732	3319
C1	16.5	8.0	---	132						
					C1 - W	120	200	27,600	0.634	1214
W. Boundary	13.5	8.0	---	108						
Totals/avg's Zone C	12.7	6.7	---	91		101	1000	103,040	2.365	4534

Cross-Section Identification (a)	Conveyance Width (Ft)	Average Soft Sediment Thickness	Depth Correction Factor	Cross-Section Area (Sq Ft)	Subzone	Average Subzone Area (b) (Sq Ft)	Length of Subzone (Ft)	Corrected Volume (c) (cubic ft.) in-place	Acre/ Feet in-place material	Weight (d) (Tons) in-place material
E. Boundary (e)	20.0	7.5	---	150						
					E. - D1	150.00	70	12,075	0.277	531
D1	20.0	7.5	---	150						
					D1 - D2	117.80	100	13,547	0.311	596
D2	10.7	8.0	---	86						
					D2 - D3	142.90	210	34,510	0.792	1518
D3	26.0	7.7	---	200						
					D3 - W	100.10	260	29,930	0.687	1317
W. Boundary (e)	26.0	7.7	---	600						
Totals/avg's Zone D	20.5	7.7	---	237		102.16	640	90,062	2.068	3963

(a) Cross-section locations from IFR report measurements. Collected at these locations. Locations shown on drawing 3.1.
(b) Subzone areas calculated using Average End Area Method. Calculations are based on field measurements of various cross sections.
(c) Corrected volume is average subzone area times length times 1.15.
(d) Average soft sediment density assumed is 88 pounds per cubic foot.
(e) Estimated Conveyance width and/or soft sediment thickness.

Notes:
1. Designations of zone prefixes were changed after IFR Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-3
SOFT SEDIMENT VOLUME ESTIMATES
PAGE FOUR

Cross-Section Identification (a)	Conveyance Width (Ft)	Average Soft Sediment Thickness	Depth Correction Factor	Cross-Section Area (Sq Ft)	Subzone	Average Subzone Area (b) (Sq Ft)	Length of Subzone (Ft)	Corrected Volume (c) (cubic ft.) in-place	Acre/ Feet in-place material	Weight (d) (Tons) in-place material
E1	18	4	0.8	57.60	E1 - E2	88.20	720	73,030	1.677	3213
E2	27	5.5	0.8	118.80						
Totals/avg's Zone E	22.5	4.75	0.80	88.20		88.20	720	73,030	1.677	3213

Cross-Section Identification (a)	Conveyance Width (Ft)	Average Soft Sediment Thickness	Depth Correction Factor	Cross-Section Area (Sq Ft)	Subzone	Average Subzone Area (b) (Sq Ft)	Length of Subzone (Ft)	Corrected Volume (c) (cubic ft.) in-place	Acre/ Feet in-place material	Weight (d) (Tons) in-place material
E Boundary	57	5	---	285	E. F1	285	240	78,660	1.806	3461
F-1	57	5.00	---	285	F1 - F2	379	150	65,377	1.501	2877
F-2	70	6.75	---	473	F2 - F3	432	100	69,552	1.597	3060
F-3	70	4.90	---	343	F3 - F7	368	80	33,810	0.776	1488
F-7	80	4.90	---	392						
Totals/avg's Zone F	66.8	5.31	---	355.50		365.81	570	247,399	5.679	10886

(a) Cross-section locations from IFR report measurements. Collected at these locations. Locations shown on drawing 3.1.
(b) Subzone areas calculated using Average End Area Method. Calculations are based on field measurements of various cross sections.
(c) Corrected volume is average subzone area times length times 1.15.
(d) Average soft sediment density assumed is 88 pounds per cubic foot.
(e) Estimated Conveyance width and/or soft sediment thickness.

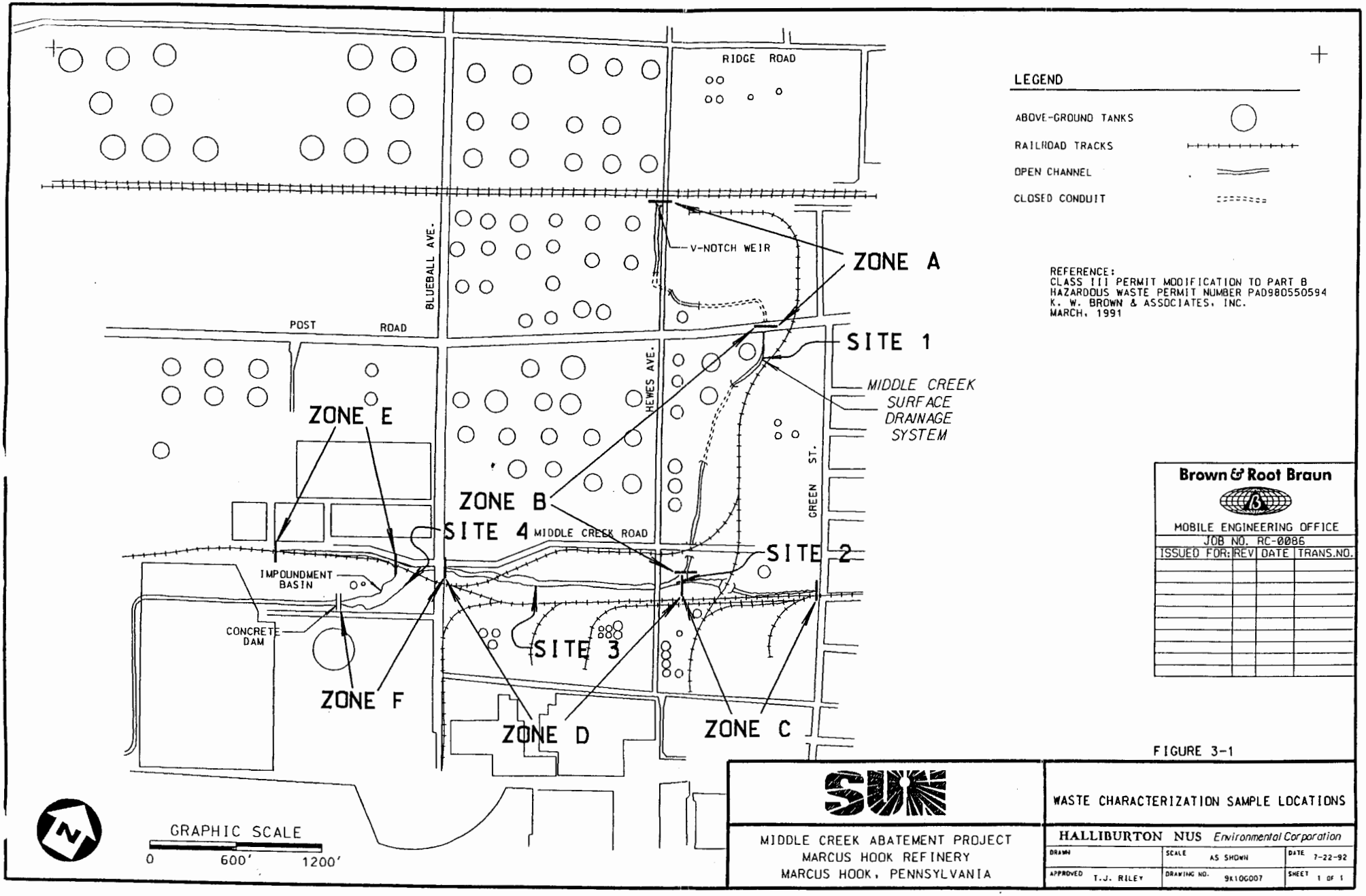
Notes:
1. Designations of zone prefixes were changed after IFR Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-3
SOFT SEDIMENT VOLUME ESTIMATES
PAGE FIVE

Cross-Section Identification (a)	Conveyance Width (Ft)	Average Soft Sediment Thickness	Depth Correction Factor	Cross-Section Area (Sq Ft)	Subzone	Average Subzone Area (b) (Sq Ft)	Length of Subzone (Ft)	Corrected Volume (c) (cubic ft.) in-place	Acre/ Feet in-place material	Weight (d) (Tons) in-place material
E. Boundary (e)	23	13.5	0.8	248.40						
G1	23	13.5	0.8	248.40	East to G1		140			
					G1 - G2	127.00	340	49,657	1.140	2185
G2	3.5	4.5	0.8	12.60						
					G2 - G3	14.30	360	5,920	0.136	260
G3	5	4	0.8	16.00						
					G3 - G4	17.38	200	3,997	0.092	176
G4	3.5	6.7	0.8	18.76						
					G4 - End	9.38	100	1,079	0.025	47
West End (e)	3.5	2.00	0.8	5.60						
Totals/avg's Zone G	12.3	0.00	0.96	109.95		42.02	1140	60,653	1.392	2669

(a) Cross-section locations from IFR report measurements. Collected at these locations. Locations shown on drawing 3.1.
(b) Subzone areas calculated using Average End Area Method. Calculations are based on field measurements of various cross sections.
(c) Corrected volume is average subzone area times length times 1.15.
(d) Average soft sediment density assumed is 88 pounds per cubic foot.
(e) Estimated Conveyance width and/or soft sediment thickness.

Notes:
1. Designations of zone prefixes were changed after IFR Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.


RIDGE ROAD
BLUEBALL AVE.
POST ROAD
HEWES AVE.
GREEN ST.
V-NOTCH WEIR
ZONE A
SITE 1
MIDDLE CREEK SURFACE DRAINAGE SYSTEM
ZONE E
ZONE B
SITE 4 MIDDLE CREEK ROAD
SITE 2
IMPOUNDMENT BASIN
CONCRETE DAM
SITE 3
ZONE F
ZONE D
ZONE C
GRAPHIC SCALE
0 600' 1200'
LEGEND
ABOVE-GROUND TANKS
RAILROAD TRACKS
OPEN CHANNEL
CLOSED CONDUIT
REFERENCE:
CLASS III PERMIT MODIFICATION TO PART B
HAZARDOUS WASTE PERMIT NUMBER PAD980550594
K. W. BROWN & ASSOCIATES, INC.
MARCH, 1991
Brown & Root Braun
MOBILE ENGINEERING OFFICE
JOB NO. RC-0086
ISSUED FOR: REV DATE TRANS.NO.
FIGURE 3-1
WASTE CHARACTERIZATION SAMPLE LOCATIONS
MIDDLE CREEK ABATEMENT PROJECT
MARCUS HOOK REFINERY
MARCUS HOOK, PENNSYLVANIA
HALLIBURTON NUS Environmental Corporation
DRAWN
SCALE AS SHOWN
DATE 7-22-92
APPROVED T.J. RILEY
DRAWING NO. 9K10G007
SHEET 1 OF 1

Modified Skinner List analyses of the four sediment samples showed the presence of various metals. The range of concentrations for the metals analyzed is as follows:

	Minimum (mg/kg)	Maximum (mg/kg)
Antimony	1.3	5.1
Arsenic	1.1	6.0
Barium	18.0	87.0
Beryllium	ND	ND
Cadmium	ND	ND
Chromium	260.0	500.0
Cobalt	ND	81.0
Copper	26	130.0
Lead	ND	110.0
Nickel	ND	33.0
Mercury	ND	1.7
Selenium	2.8	4.1
Vanadium	ND	25.0
Zinc	110.0	430.0

Petroleum hydrocarbons and benzene, toluene, and xylene (BTX) were found at levels ranging from nondetectable to detectable at 129 mg/kg. The range of concentrations for BTX constituents is as follows:

	Minimum (mg/kg)	Maximum (mg/kg)
Benzene	ND	94.0
Toluene	ND	8.0
Xylene	12.2	129.0

Concentrations of semivolatile compounds, such as polynuclear aromatic hydrocarbons (PAHs), were found in concentrations ranging from nondetectable up to a maximum of 1100 mg/kg. Of the semivolatile compounds detected, most were detected at concentrations typically in the hundreds of milligrams per kilogram range. In general, concentrations of all constituents increased from the upstream sample location to the downstream sample location.

The mobility (leachability) of the compounds detected is very low. Analytical data further indicated that although modified Skinner List concentrations of individual metals, organic volatiles, and semivolatile PAHs were detected, comparable concentrations of individual compounds in TCLP leachate of the soft sediment samples were very low. This indicates that these compounds were not mobile. Benzene, a volatile organic compound (VOC), was the only organic constituent routinely detected in the TCLP leachate, and only one sample indicated a benzene concentration above the regulatory level of 0.5 ppm (EPA, 55 FR 11796, March 29,1990; 55 FR 26986, June 29, 1990).

High moisture content was typical for the four sediment samples, in addition to variable amounts of PAHs, and oil and grease. The oil and grease content ranged from 2.5 percent to 21 percent, and the moisture content from 48 percent to 66 percent.

3.2.2 Initial Field Reconnaissance Phase I

The intent of the IFR Phase I was to characterize the Middle Creek Conveyance by estimating the volume of soft sediment and analyzing selected samples for physical and chemical parameters. The task of estimating the soft sediment volume has been discussed previously in this section; the locations identified in that discussion correspond to locations of samples used for sediment characterization.

During the IFR, 6 samples of soft sediment and 26 samples of underlying sediment were collected. Underlying sediment samples were taken at nearly all of the sample locations within each zone. The six soft sediment samples were taken within three zones (B, D, and F) at locations intended to be representative of the Conveyance soft sediment in regard to both volume and chemical and physical characteristic. The samples were taken in locations associated with relatively large volumes of sediment and which were representative of the variability in soft sediment characteristic. Location B4 is at a point downstream of oil/water separators 1A, 10 and 1C. Location D1 is downstream of the confluence of the conveyance segments and location F1. F2 is located downstream of the 15 plant separator influent where the conveyance enters the pH Basin. The evaluation of soft sediment samples is discussed further in Section 4.4, where soft sediments are the subject of the treatability study.

The 6 soft sediment and 26 underlying sediment samples were collected and sent to a laboratory for TCLP and/or total petroleum hydrocarbon (TPH) analyses. The six soft sediment samples were also analyzed for "as received" constituents (modified Skinner List and others). These results compare with those previously discussed for the Class III permit modification, and are presented in Appendix 3.1

(Volume 3). Table 3-4 presents the TCLP and/or TPH analytical results for the six soft sediment samples. Table 3-5 presents the TCLP and/or TPH analytical results for the 26 underlying sediment samples. Both tables also list TC regulatory levels for comparison. Eight soft sediment samples were collected and analyzed for various geotechnical properties. Results from six of these samples are discussed in Section 2.1.3. Appendix 3.1 (Volume 3) contains all IFR Phase I analytical results. The following subsections discuss the TCLP and TPH analytical results only.

3.2.2.1 Toxicity Characteristic Leaching Procedure Results - Soft Sediment

Table 3-4 presents a summary of the analytical results for TCLP analysis of the six samples of soft sediment representing Zones B, D, and F. Two samples per zone were collected: one shallow (S), and one from deeper, more dense soft sediment (D). Typically, the deeper sample in each zone showed slightly lower concentrations of all contaminants. However, all reported concentrations (organic and inorganic) were below TC regulatory levels.

Benzene, a VOC, was detected in the extract from each sample at concentrations ranging from 0.005 mg/l in Zone B to 0.42 mg/l in Zone F, all below the TCLP regulatory level of 0.50. Several metals were detected at levels below the TC regulatory levels. Following is a summary of the results.

Constituent	Range (mg/l)	TC Limit (mg/l)
Arsenic	ND - ND	5.0
Barium	0.44 - 0.82	100.0
Cadmium	ND - 0.03	1.0
Chromium	0.13 - 0.65	5.0
Lead	ND - 0.20	5.0
Mercury	ND - 0.004	0.2
Silver	0.12 - 0.18	5.0
Selenium	ND - ND	1.0
Benzene	0.005 - 0.42	0.5

In summary, the toxicity characteristic leaching procedure data show that hazardous constituents of the soft sediment samples tested well below levels which characterize the sediments as hazardous.

TABLE 3-4
ZONES B, D AND F: SUMMARY OF ANALYTICAL RESULTS, TCLP AND TPH ANALYSES OF SOFT SEDIMENT SAMPLES

PARAMETER	SAMPLE IDENTIFICATION						PQL (mg/l)	TC REGULATORY LEVEL (a) mg/l	EPA METHOD USED
	B4D	B4S	D1D	D1S	F2D	F1S			
Volatile Compounds on TCLP Extract, mg/l									
Benzene	0.005	0.015	0.006	0.018	0.11	0.42	0.005	0.5	8420
Carbon Tetrachloride	nd	nd	nd	nd	nd	nd	0.005	0.5	8420
Chlorobenzene	nd	nd	nd	nd	nd	nd	0.005	100.0	8420
Chloroform	nd	nd	nd	nd	nd	nd	0.005	6.0	8420
1,4-Dichlorobenzene	nd	nd	nd	nd	nd	nd	0.005	7.5	8420
1,2-Dichloroethane	nd	nd	nd	nd	nd	nd	0.005	0.5	8420
1,1-Dichloroethylene	nd	nd	nd	nd	nd	nd	0.005	0.7	8420
Methyl Ethyl Ketone	nd	nd	nd	nd	nd	nd	0.005	200.0	8420
Tetrachloroethylene	nd	nd	nd	nd	nd	nd	0.005	0.7	8420
Trichloroethylene	nd	nd	nd	nd	nd	nd	0.005	0.5	8420
Vinyl Chloride	nd	nd	nd	nd	nd	nd	0.005	0.2	8420
Semivolatile Compounds on TCLP Extract, mg/l									
o-Cresol	nd	nd	nd	nd	nd	nd	0.01	200.0	8720
m-Cresol	nd	nd	nd	nd	nd	nd	0.01	200.0	8720
p-Cresol	nd	nd	nd	nd	nd	nd	0.01	200.0	8720
2,4-Dinitrotoluene	nd	nd	nd	nd	nd	nd	0.01	0.13	8720
Hexachlorobenzene	nd	nd	nd	nd	nd	nd	0.01	0.13	8720
Hexachloro-1,3-butadiene	nd	nd	nd	nd	nd	nd	0.01	0.5	8720
Hexachloroethane	nd	nd	nd	nd	nd	nd	0.01	3.0	8720
Nitrobenzene	nd	nd	nd	nd	nd	nd	0.01	2.0	8720
Pentachlorophenol	nd	nd	nd	nd	nd	nd	0.01	100.0	8720
Pyridine	nd	nd	nd	nd	nd	nd	0.005	5.0	8720
2,4,5-Trichlorophenol	nd	nd	nd	nd	nd	nd	0.01	400.0	8720
2,4,6-Trichlorophenol	nd	nd	nd	nd	nd	nd	0.01	2.0	8720

(a) Source: EPA, 55 FR 11796, March 29, 1990; 55 FR 26986, June 29, 1990.

nd = not detected at or below the Practical Quantitation Limit (PQL) listed for the method performed.
nl = none listed per (a).

Notes:

1. Designations of zone prefixes were changed after IFR Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-4
ZONES B, D AND F: SUMMARY OF ANALYTICAL RESULTS,
TCLP AND TPH ANALYSES OF SOFT SEDIMENT SAMPLES
PAGE TWO

PARAMETER	SAMPLE IDENTIFICATION						PQL (mg/l)	TC REGULATORY LEVEL (a) mg/l	EPA METHOD USED
	B4D	B4S	D1D	D1S	F2D	F1S			
Volatile Compounds-PAHS on TCLP Extract, mg/l									
Naphthalene	0.011	0.009	0.012	0.017	0.006	0.021	0.001	nl	8720
Acenaphthylene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Acenaphthene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Fluorene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Phenanthrene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Anthracene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Fluoranthene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Pyrene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Benzo (a) anthracene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Chrysene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Benzo (b) fluoranthene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Benzo (k) fluoranthene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Benzo (a) pyrene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Benzo (g,h,i) perylene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Dibenzo (a,h) anthracene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
Indeno (1,2,3-cd) pyrene	nd	nd	nd	nd	nd	nd	0.001	nl	8720
bis (2-Chloroisopropyl) ether	nd	nd	nd	nd	nd	nd	0.001	nl	8720
bis (2-Chloroethyl) ether	nd	nd	nd	nd	nd	nd	0.001	nl	8720
bis (2-Chloroethoxy) methane	nd	nd	nd	nd	nd	nd	0.001	nl	8720
4-Chlorophenyl Phenyl Ether	nd	nd	nd	nd	nd	nd	0.001	nl	8720
4-Bromophenyl Phenyl Ether	nd	nd	nd	nd	nd	nd	0.001	nl	8720

(a) Source: EPA, 55 FR 11796, March 29, 1990; 55 FR 26986, June 29, 1990.

nd = not detected at or below the Practical Quantitation Limit (PQL) listed for the method performed.
nl = none listed per (a).

Notes:

1. Designations of zone prefixes were changed after IFR Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-4 **TABLE 3-4**
ZONES B, D AND F: SUMMARY OF ANALYTICAL RESULTS,
TCLP AND TPH ANALYSES OF SOFT SEDIMENT SAMPLES
PAGE THREE

PARAMETER	SAMPLE IDENTIFICATION						PQL (mg/l)	TC REGULATORY LEVEL (a) mg/l	EPA METHOD USED
	B4D	B4S	D1D	D1S	F2D	F1S			
Pesticides on TCLP extracts, mg/l									
Chlordane	nd	nd	nd	nd	nd	nd	0.001	0.03	8080
Endrin	nd	nd	nd	nd	nd	nd	0.001	0.02	8080
Heptachlor	nd	nd	nd	nd	nd	nd	0.0001	0.008	8080
Lindane	nd	nd	nd	nd	nd	nd	0.0001	0.4	8080
Methoxychlor	nd	nd	nd	nd	nd	nd	0.001	10.0	8080
Toxaphene	nd	nd	nd	nd	nd	nd	0.001	0.5	8080
Herbicides on TCLP Extract, mg/l									
2,4,-D	nd	nd	nd	nd	nd	nd	0.0002	10.0	8150
2,4,5-TP	nd	nd	nd	nd	nd	nd	0.0002	1.0	8150
Metals on TCLP Extract, mg/l									
Arsenic	nd	nd	nd	nd	nd	nd	0.1	5.0	6010
Barium	0.44	0.57	0.51	0.63	0.63	0.82	0.05	100.0	6010
Cadmium	0.03	0.03	0.03	nd	0.02	0.03	0.02	1.0	6010
Chromium	0.55	0.56	0.16	0.49	0.13	0.65	0.02	5.0	6010
Lead	0.1	0.2	nd	nd	0.1	0.100	0.1	5.0	6010
Mercury	nd	nd	0.004	0.002	0.002	0.002	0.002	0.2	7470
Selenium	nd	nd	nd	nd	nd	nd	0.050	1.0	6010
Silver	0.12	0.18	0.17	0.12	0.12	0.13	0.02	5.0	6010
Total Petroleum Hydrocarbons, mg/kg	**15700**	**35400**	**60400**	**43400**	**48600**	**68200**	**2000**	**—**	**418.1**

(a) Source: EPA, 55 FR 11796, March 29, 1990; 55 FR 26986, June 29, 1990.

nd = not detected at or below the Practical Quantitation Limit (PQL) listed for the method performed.
nl = none listed per (a).

Notes:

1. Designations of zone prefixes were changed after IFR Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-5
ZONES A, B, AND C: SUMMARY OF ANALYTICAL RESULTS, TCLP AND TPH ANALYSES OF UNDERLYING SEDIMENT SAMPLES

PARAMETER	SAMPLE IDENTIFICATION											PQL (mg/l)	TC REGULATORY LEVELS (a) mg/l	EPA METHOD USED
	A11	A31	A51	A61	A81	B31	B41	B51	B61	C11	C21			
Volatile Compounds onTCLP Extract, mg/l														
Benzene	nd	0.01	0.01	na	na	0.01	nd	0.01	nd	0.09	0.02	0.005	0.5	8420
Carbon Tetrachloride	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	0.5	8420
Chlorobenzene	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	100.0	8420
Chloroform	0.01	0.01	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	6.0	8420
1,4-Dichlorobenzene	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	7.5	8420
1,2-Dichloroethane	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	0.5	8420
1,1-Dichloroethylene	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	0.7	8420
Methyl Ethyl Ketone	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	200.0	8420
Tetrachloroethylene	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	0.7	8420
Trichloroethylene	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	0.5	8420
Vinyl Chloride	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	0.2	8420
Semivolatile Compounds on TCLP Extract, mg/l														
o-Cresol	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	200.0	8720
m-Cresol	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	200.0	8720
p-Cresol	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	200.0	8720
2,4-Dinitrotoluene	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	0.13	8720
Hexachlorobenzene	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	0.13	8720
Hexachloro-1,3-butadiene	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	0.5	8720
Hexachloroethane	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	3.0	8720
Nitrobenzene	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	2.0	8720
Pentachlorophenol	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	100.0	8720
Pyridine	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	5.0	8720
2,4,5-Trichlorophenol	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	400.0	8720
2,4,6-Trichlorophenol	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.005	2.0	8720

(a) Source: EPA, 55FR 11796, March 29, 1990; 55FR 26986, June 29, 1990.
nd= not detected at or below Practical Quantitation Limit (PQL)
na= not analyzed

Notes:
1. Designations of zone prefixes were changed after Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-5
ZONES A, B, AND C: SUMMARY OF ANALYTICAL RESULTS, TCLP AND TPH ANALYSES OF UNDERLYING SEDIMENT SAMPLES
PAGE TWO

PARAMETER	SAMPLE IDENTIFICATION											PQL (mg/l)	TC REGULATORY LEVELS (a) mg/l	EPA METHOD USED
	A11	A31	A51	A61	A81	B31	B41	B51	B61	C11	C21			
Pesticides on TCLP Extract, mg/l														
Chlordane	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.001	0.03	8080
Endrin	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.001	0.02	8080
Heptachlor	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.0001	0.008	8080
Lindane	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.0001	0.4	8080
Methoxychlor	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.001	10.0	8080
Toxaphene	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.001	0.5	8080
Herbicides on TCLP Extract, mg/l														
2,4,-D	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.0002	10.0	8150
2,4,5-TP	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.0002	1.0	8150
Materials on TCLP Extract, mg/l														
Arsenic	nd	nd	nd	na	na	nd	nd	nd	nd	nd	nd	0.1	5.0	6010
Barium	0.4	0.42	0.47	na	na	0.08	0.16	0.29	0.43	0.33	0.16	0.05	100.0	6010
Cadmium	nd	nd	nd	na	na	nd	nd	0.04	0.03	nd	nd	0.02	1.0	6010
Chromium	nd	nd	nd	na	na	0.06	0.02	0.13	0.06	0.03	0.03	0.02	5.0	6010
Lead	nd	nd	0.2	na	na	0.4	nd	nd	nd	nd	nd	0.1	5.0	6010
Mercury	nd	nd	nd	na	na	nd	nd	nd	nd	0.003	nd	0.002	0.2	7470
Selenium	0.24	nd	nd	na	na	nd	0.15	nd	nd	nd	0.23	0.05	1.0	6010
Silver	0.07	0.08	0.05	na	na	0.1	0.04	0.09	0.09	0.03	0.03	0.02	5.0	6010
Total Petroleum Hydrocarbons, mg/kg	**105**	**215**	**20**	**75**	**190**	**4700**	**190**	**4520**	**690**	**9300**	**375**	**5**	**na**	**418.1**

(a) Source: EPA, 55FR 11796, March 29, 1990; 55FR 26986, June 29, 1990.
nd= not detected at or below Practical Quantitation Limit (PQL)
na= not analyzed
Notes:
1. Designations of zone prefixes were changed after Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-5
ZONES D AND E: SUMMARY OF ANALYTICAL RESULTS, TCLP AND TPH ANALYSES OF UNDERLYING NATIVE SEDIMENT SAMPLES
PAGE THREE

PARAMETER	SAMPLE IDENTIFICATION					PQL (mg/l)	TC REGULATORY LEVELS (a) mg/l	EPA METHOD USED
	D11	D21	D32	E11	E23			
Volatile Compounds on TCLP Extract, mg/l								
Benzene	nd	nd	nd	nd	nd	0.005	0.5	8420
Carbon Tetrachloride	nd	nd	nd	nd	nd	0.005	0.5	8420
Chlorobenzene	nd	nd	nd	nd	nd	0.005	100.0	8420
Chloroform	nd	nd	0.01	nd	0.01	0.005	6.0	8420
1,4-Dichlorobenzene	nd	nd	nd	nd	nd	0.005	7.5	8420
1,2-Dichloroethane	nd	nd	nd	nd	nd	0.005	0.5	8420
1,1-Dichloroethylene	nd	nd	nd	nd	nd	0.005	0.7	8420
Methyl Ethyl Ketone	nd	nd	nd	0.01	nd	0.005	200.0	8420
Tetrachloroethylene	nd	nd	nd	nd	nd	0.005	0.7	8420
Trichloroethylene	nd	nd	nd	nd	nd	0.005	0.5	8420
Vinyl Chloride	nd	nd	nd	nd	nd	0.005	0.2	8420
Semivolatile Compounds on TCLP Extract, mg/l								
o-Cresol	nd	nd	nd	nd	nd	0.005	200.0	8720
m-Cresol	nd	nd	nd	nd	nd	0.005	200.0	8720
p-Cresol	nd	nd	nd	nd	nd	0.005	200.0	8720
2,4-Dinitrotoluene	nd	nd	nd	nd	nd	0.005	0.13	8720
Hexachlorobenzene	nd	nd	nd	nd	nd	0.005	0.13	8720
Hexachloro-1,3-butadiene	nd	nd	nd	nd	nd	0.005	0.5	8720
Hexachloroethane	nd	nd	nd	nd	nd	0.005	3.0	8720
Nitrobenzene	nd	nd	nd	nd	nd	0.005	2.0	8720
Pentachlorophenol	nd	nd	nd	nd	nd	0.005	100.0	8720
Pyridine	nd	nd	nd	nd	nd	0.005	5.0	8720
2,4,5-Trichlorophenol	nd	nd	nd	nd	nd	0.005	400.0	8720
2,4,6-Trichlorophenol	nd	nd	nd	nd	nd	0.005	2.0	8720

(a) Source: EPA, 55FR 11796, March 29, 1990; 55FR 26986, June 29, 1990.
nd= not detected at or below Practical Quantitation Limit (PQL)
na= not analyzed
Notes:
1. Designations of zone prefixes were changed after Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-5
ZONES D AND E: SUMMARY OF ANALYTICAL RESULTS, TCLP AND TPH ANALYSES OF UNDERLYING NATIVE SEDIMENT SAMPLES
PAGE FOUR

PARAMETER	SAMPLE IDENTIFICATION					PQL (mg/l)	TC REGULATORY LEVELS (a) mg/l	EPA METHOD USED
	D11	D21	D32	E11	E23			
Pesticides on TCLP Extract, mg/l								
Chlordane	nd	nd	nd	nd	nd	0.001	0.03	8080
Endrin	nd	nd	nd	nd	nd	0.001	0.02	8080
Heptachlor	nd	nd	nd	nd	nd	0.0001	0.008	8080
Lindane	nd	nd	nd	nd	nd	0.0001	0.4	8080
Methoxychlor	nd	nd	nd	nd	nd	0.001	10.0	8080
Toxaphene	nd	nd	nd	nd	nd	0.001	0.5	8080
Herbicides on TCLP Extract, mg/l								
2,4,-D	nd	nd	nd	nd	nd	0.0002	10.0	8150
2,4,5-TP	nd	nd	nd	nd	nd	0.0002	1.0	8150
Metals on TCLP Extract, mg/l								
Arsenic	nd	nd	nd	nd	nd	0.1	5.0	6010
Barium	0.12	0.27	0.53	0.62	0.33	0.05	100.0	6010
Cadmium	nd	0.02	nd	nd	nd	0.02	1.0	6010
Chromium	nd	0.03	0.04	0.03	0.02	0.02	5.0	6010
Lead	nd	0.1	nd	nd	0.1	0.1	5.0	6010
Mercury	nd	nd	0.01	0.007	0.002	0.002	0.2	7470
Selenium	nd	nd	0.17	nd	nd	0.05	1.0	6010
Silver	0.02	0.03	0.02	0.02	0.02	0.02	5.0	6010
Total Petroleum Hydrocarbons, mg/kg	420	50	35	60	145	5	.....	418.1

(a) Source: EPA, 55FR 11796, March 29, 1990; 55FR 26986, June 29, 1990.
nd= not detected at or below Practical Quantitation Limit (PQL)
na= not analyzed
Notes:
1. Designations of zone prefixes were changed after Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-5
ZONE F: SUMMARY OF ANALYTICAL RESULTS, TOXICITY CHARACTERISTIC LEACHING PROCEDURE PERFORMED ON UNDERLYING SEDIMENT
PAGE FIVE

PARAMETER	SAMPLE IDENTIFICATION						PQL (mg/l)	TC REGULATORY LEVELS (a) mg/l	EPA METHOD USED
	F13	F21	F31	F41	F53	F71			
Volatile Compounds on TCLP Extract, mg/l									
Benzene	nd	0.005	nd	nd	nd	0.005	0.005	0.5	8420
Carbon Tetrachloride	nd	nd	nd	nd	nd	nd	0.005	0.5	8420
Chlorobenzene	nd	nd	nd	nd	nd	nd	0.005	100.0	8420
Chloroform	nd	nd	nd	nd	nd	nd	0.005	6.0	8420
1,4-Dichlorobenzene	nd	nd	nd	nd	nd	nd	0.005	7.5	8420
1,2-Dichloroethane	nd	nd	nd	nd	nd	nd	0.005	0.5	8420
1,1-Dichloroethylene	nd	nd	nd	nd	nd	nd	0.005	0.7	8420
Methyl Ethyl Ketone	nd	nd	nd	nd	nd	nd	0.005	200.0	8420
Tetrachloroethylene	nd	nd	nd	nd	nd	nd	0.005	0.7	8420
Trichloroethylene	nd	nd	nd	nd	nd	nd	0.005	0.5	8420
Vinyl Chloride	nd	nd	nd	nd	nd	nd	0.005	0.2	8420
Semivolatile Compounds on TCLP Extract, mg/l									
o-Cresol	nd	nd	nd	nd	nd	nd	0.005	200.0	8720
m-Cresol	nd	nd	nd	nd	nd	nd	0.005	200.0	8720
p-Cresol	nd	nd	nd	nd	nd	nd	0.005	200.0	8720
2,4-Dinitrotoluene	nd	nd	nd	nd	nd	nd	0.005	0.13	8720
Hexachlorobenzene	nd	nd	nd	nd	nd	nd	0.005	0.13	8720
Hexachloro-1,3-butadiene	nd	nd	nd	nd	nd	nd	0.005	0.5	8720
Hexachloroethane	nd	nd	nd	nd	nd	nd	0.005	3.0	8720
Nitrobenzene	nd	nd	nd	nd	nd	nd	0.005	2.0	8720
Pentachlorophenol	nd	nd	nd	nd	nd	nd	0.005	100.0	8720
Pyridine	nd	nd	nd	nd	nd	nd	0.005	5.0	8720
2,4,5-Trichlorophenol	nd	nd	nd	nd	nd	nd	0.005	400.0	8720
2,4,6-Trichlorophenol	nd	nd	nd	nd	nd	nd	0.005	2.0	8720

(a) Source: EPA, 55FR 11796, March 29, 1990; 55FR 26986, June 29, 1990.
nd= not detected at or below Practical Quantitation Limit (PQL)
na= not analyzed
Notes:
1. Designations of zone prefixes were changed after Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-5
ZONE F: SUMMARY OF ANALYTICAL RESULTS, TOXICITY CHARACTERISTIC LEACHING PROCEDURE PERFORMED ON UNDERLYING SEDIMENT
PAGE SIX

PARAMETER	SAMPLE IDENTIFICATION						PQL (mg/l)	TC REGULATORY LEVELS (a) mg/l	EPA METHOD USED
	F13	F21	F31	F41	F53	F71			
Pesticides on TCLP extracts, mg/l									
Chlordane	nd	nd	nd	nd	nd	nd	0.001	0.03	8080
Endrin	nd	nd	nd	nd	nd	nd	0.001	0.02	8080
Heptachlor	nd	nd	nd	nd	nd	nd	0.0001	0.008	8080
Lindane	nd	nd	nd	nd	nd	nd	0.0001	0.4	8080
Methoxychlor	nd	nd	nd	nd	nd	nd	0.001	10.0	8080
Toxaphene	nd	nd	nd	nd	nd	nd	0.001	0.5	8080
Herbicides on TCLP Extract, mg/l									
2,4,-D	nd	nd	nd	nd	nd	nd	0.0002	10.0	8150
2,4,5-TP	nd	nd	nd	nd	nd	nd	0.0002	1.0	8150
Metals on TCLP Extract, mg/l									
Arsenic	0.1	nd	0.2	0.1	nd	0.2	0.1	5.0	6010
Barium	0.33	0.33	0.28	0.2	0.39	0.32	0.05	100.0	6010
Cadmium	nd	nd	nd	nd	nd	nd	0.02	1.0	6010
Chromium	0.02	nd	nd	nd	0.03	0.07	0.02	5.0	6010
Lead	nd	nd	nd	nd	nd	nd	0.1	5.0	6010
Mercury	0.04	nd	nd	nd	nd	nd	0.002	0.2	7470
Selenium	nd	nd	nd	nd	nd	nd	0.05	1.0	6010
Silver	nd	nd	nd	nd	0.03	0.1	0.02	5.0	6010
Total Petroleum Hydrocarbons, mg/kg	350	85	1260	400	nd	105	5.0	----	418.1

(a) Source: EPA, 55FR 11796, March 29, 1990; 55FR 26986, June 29, 1990.
nd= not detected at or below Practical Quantitation Limit (PQL)
na= not analyzed

Notes:
1. Designations of zone prefixes were changed after Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-5
ZONE G: SUMMARY OF ANALYTICAL RESULTS, TOXICITY CHARACTERISTIC
PAGE SEVEN

PARAMETER	SAMPLE IDENTIFICATION G11	G21	G31	G41	PQL (mg/l)	TC REGULATORY LEVELS (a) mg/l	EPA METHOD USED
Volatile Compounds on TCLP Extract, mg/l							
Benzene	nd	0.005	nd	nd	0.005	0.5	8420
Carbon Tetrachloride	nd	nd	nd	nd	0.005	0.5	8420
Chlorobenzene	nd	nd	nd	nd	0.005	100.0	8420
Chloroform	nd	nd	nd	0.007	0.005	6.0	8420
1,4-Dichlorobenzene	nd	nd	nd	nd	0.005	7.5	8420
1,2-Dichloroethane	nd	nd	nd	nd	0.005	0.5	8420
1,1-Dichloroethylene	nd	nd	nd	nd	0.005	0.7	8420
Methyl Ethyl Ketone	nd	nd	nd	nd	0.005	200.0	8420
Tetrachloroethylene	nd	nd	nd	nd	0.005	0.7	8420
Trichloroethylene	nd	nd	nd	nd	0.005	0.5	8420
Vinyl Chloride	nd	nd	nd	nd	0.005	0.2	8420
Semivolatile Compounds on TCLP Extract, mg/l							
o-Cresol	nd	nd	nd	nd	0.005	200.0	8720
m-Cresol	nd	nd	nd	nd	0.005	200.0	8720
p-Cresol	nd	nd	nd	nd	0.005	200.0	8720
2,4-Dinitrotoluene	nd	nd	nd	nd	0.005	0.13	8720
Hexachlorobenzene	nd	nd	nd	nd	0.005	0.13	8720
Hexachloro-1,3-butadiene	nd	nd	nd	nd	0.005	0.5	8720
Hexachloroethane	nd	nd	nd	nd	0.005	3.0	8720
Nitrobenzene	nd	nd	nd	nd	0.005	2.0	8720
Pentachlorophenol	nd	nd	nd	nd	0.005	100.0	8720
Pyridine	nd	nd	nd	nd	0.005	5.0	8720
2,4,5-Trichlorophenol	nd	nd	nd	nd	0.005	400.0	8720
2,4,6-Trichlorophenol	nd	nd	nd	nd	0.005	2.0	8720

(a) Source: EPA, 55FR 11796, March 29, 1990; 55FR 26986, June 29, 1990.
nd= not detected at or below Practical Quantitation Limit (PQL)
na= not analyzed

Notes:
1. Designations of zone prefixes were changed after Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

TABLE 3-5
ZONE G: SUMMARY OF ANALYTICAL RESULTS, TOXICITY CHARACTERISTIC
PAGE EIGHT

PARAMETER	SAMPLE IDENTIFICATION G11	G21	G31	G41	PQL (mg/l)	TC REGULATORY LEVELS (a) mg/l	EPA METHOD USED
Volatile Compounds on TCLP Extract, mg/l							
Chlordane	nd	nd	nd	nd	0.001	0.03	8080
Endrin	nd	nd	nd	nd	0.001	0.02	8080
Heptachlor	nd	nd	nd	nd	0.0001	0.008	8080
Lindane	nd	nd	nd	nd	0.0001	0.4	8080
Methoxychlor	nd	nd	nd	nd	0.001	10.0	8080
Toxaphene	nd	nd	nd	nd	0.001	0.5	8080
Herbicides on TCLP Extract, mg/l							
2,4,-D	nd	nd	nd	nd	0.0002	10.0	8150
2,4,5-TP	nd	nd	nd	nd	0.0002	1.0	8150
Metals on TCLP Extract, mg/l							
Arsenic	nd	0.2	nd	nd	0.1	5.0	6010
Barium	0.28	0.4	0.38	0.16	0.05	100.0	6010
Cadmium	nd	nd	nd	nd	0.02	1.0	6010
Chromium	nd	nd	0.03	0.03	0.02	5.0	6010
Lead	0.1	nd	nd	nd	0.1	5.0	6010
Mercury	nd	nd	nd	nd	0.002	0.2	7470
Selenium	0.26	nd	nd	nd	0.05	1.0	6010
Silver	nd	0.02	0.06	0.09	0.02	5.0	6010
Total Petroleum Hydrocarbons, mg/kg	75	30	270	160	5	.....	418.1

(a) Source: EPA, 55FR 11796, March 29, 1990; 55FR 26986, June 29, 1990.
nd= not detected at or below Practical Quantitation Limit (PQL)
na= not analyzed

Notes:
1. Designations of zone prefixes were changed after Phase I. See Section 3.1.1 .
2. All samples were collected during IFR Phase I, 12/4/91 through 1/20/92.

3.2.2.2 Toxicity Characteristic Leaching Procedure Results - Underlying Sediment

Table 3-5 presents a summary of the analytical results for TCLP analysis of the 26 samples of underlying sediment representing Zones A through G. In most cases organics were not detected in the TC leachates. Benzene and/or chloroform were the only organic compounds detected in each zone, with the exception of one detection of methyl ethyl ketone in Zone E. Of the inorganic constituents barium, chromium, and silver were routinely detected in all zones, with the exception of chromium, which was not detected in Zone A. Other inorganic constituents include arsenic in Zones F and G; cadmium in Zones B and D; lead in Zones A, B, D, E, and G; mercury in Zones C, D, E, and F; and selenium in Zones A, B, C, D, and G. All reported concentrations (organic and inorganic) were below any applicable TC regulatory levels. Following is a discussion for each zone of samples showing concentrations of any parameter above detection limits.

	Constituent Detected	Detected Range (mg/l)	TC Limit (mg/l)
Zone A			
	Benzene	0.01	0.5
	Chloroform	0.1	6.0
	Barium	0.40 - 0.47	100.0
	Lead	0.2	5.0
	Selenium	0.24	1.0
	Silver	0.05 - 0.08	5.0
Zone B			
	Benzene	0.01	0.5
	Barium	0.08 - 0.43	100.0
	Cadmium	0.03 - 0.04	1.0
	Chromium	0.02 - 0.13	5.0
	Lead	0.40	5.0
	Selenium	0.15	1.0
	Silver	0.04 - 0.1	5.0
Zone C			
	Benzene	0.02 - 0.09	0.5
	Barium	0.16 - 0.33	100.0
	Chromium	0.03	5.0
	Mercury	0.003	0.2
	Selenium	0.23	1.0
	Silver	0.03	5.0

Zone D			
	Choloform	0.01	6.0
	Methyl Ethyl Ketone	0.01	200.0
	Barium	0.12 - 0.62	100.0
	Cadmium	0.02	1.0
	Chromium	0.02 - 0.04	5.0
	Lead	0.10	5.0
	Mercury	0.002 - 0.010	0.2
	Silver	0.02 - 0.03	5.0

Constituent Detected	Detected Range (mg/l)	TC Limit (mg/l)
Zone E		
Arsenic	0.10 - 0.20	5.0
Barium	0.02 - 0.39	100.0
Chromium	0.02 - 0.07	5.0
Mercury	0.04	0.2
Silver	0.02	5.0
Zone F		
Benzene	0.005	0.5
Chloroform	0.007	6.0
Arsenic	0.2	5.0
Barium	0.16 - 0.40	100.0
Chromium	0.03	5.0
Selenium	0.26	1.0
Silver	0.03 - 0.10	5.0

These data show that few organic compounds were detected in the TCLP extract of the underlying sediment. Those organics that were detected were all present at levels well below TCLP extract limits. Metals found in leachates underlying sediment were also all present at concentrations well below the TC limits.

3.2.2.3 Total Petroleum Hydrocarbon (TPH) Results

The TPH concentration was determined for the six soft sediment samples and the 26 underlying sediment samples using EPA Method 418.1. The TPH for soft sediment concentrations ranged from 15,700 mg/kg (Zone B) to 68,200 mg/kg (Zone F) (Table 3-4). Generally, the TPH concentrations were slightly lower in the samples collected from deeper intervals within the soft sediment column.

The TPH concentrations for underlying sediment sample in Zones A, D, E, and G (Table 3-5) exhibited concentrations ranging from 20 to 420 mg/kg; underlying sediment in Zone C exhibited the highest concentration of 9300 mg/kg; In Zone B, underlying sediment exhibited two concentrations between 4500 and 5000 mg/kg; and Zone F underlying sediment exhibited concentrations ranging from 85 to 1260 mg/kg.

3.3 GROUNDWATER ANALYTICAL DATA

The shallow groundwater system at the Marcus Hook refinery is considered to be the Trenton Gravel of Pleistocene age. This unit consists of gravelly sand with beds of sandy and clayey silt. The Trenton Gravel is underlain by metamorphic bedrock, which has extremely low primary porosity and little development of fracturing. Therefore, there are no underlying aquifers hydraulically connected to this uppermost aquifer. The uppermost aquifer is generally unconfined, although some confining conditions may be present locally where finer grained silts and clays overlie gravels.

Groundwater quality data have been obtained in the vicinity of the Conveyance. Analytical results from December 1991 samples from Wells 45 and 17 are shown in Table 3-6. The locations of Wells 45 and 17 are shown in Drawing 1-0-5A/25053A (Volume 2). Each well is screened from 3 to 8 feet across a silty sediment interval. Groundwater from Well 45, located approximately 650 feet upgradient of the Conveyance, was analyzed for organic compounds. Even though these wells are not used as drinking water sources, the analysis included a comparison of several organic analyte concentrations against maximum contaminant levels (MCLs) for drinking water. Cyclohexane, benzene, toluene, 1-methylnaph-thalene, fluorene, and phenanthrene were reported above detection limits in Well 45. Benzene was found at a level above the MCL. Chloroform was the only compound detected in Well 17, which is located approximately 700 feet downgradient of the north/south portion of the Conveyance. Metals were detected but all at concentrations well below the MCLs for drinking water.

TABLE 3-6
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
WELLS 45 AND 17

PARAMETER	WELL 45(a)	WELL 17(a)	DRINKING WATER MAXIMUM CONTAMINANT LEVELS, mg/l
Volatile Organic Compounds	mg/l	mg/l	
Carbon Disulfide	nd	nd	
Chloroform	nd	0.012	
Cyclohexane	0.028	nd	
1,2-Dichloroethane	nd	nd	0.005
2-Butanone	nd	nd	
1,2-Dibromoethane	nd	nd	
Benzene	0.020	nd	0.005
Toluene	0.006	nd	1.0
Chlorobenzene	nd	nd	
Ethylbenzene	nd	nd	0.7
Styrene	nd	nd	0.1
Xylene (total)	nd	nd	10
Semivolatile Organic Compounds, mg/l			
Pyridine	nd	nd	
Benzenethiol	nd	nd	
Phenol	nd	nd	
1,3-Dichlorobenzene	nd	nd	0.075
1,4-Dichlorobenzene	nd	nd	
1,2-Dichlorobenzene	nd	nd	0.6
Indene	nd	nd	
2-Methylphenol	nd	nd	
4-Methylphenol	nd	nd	
2,4-Dimethylphenol	nd	nd	
Naphthalene	nd	nd	
Quinoline	nd	nd	
2-Methylnaphtalene	nd	nd	
1-Methylnaphtalene	0.022	nd	
Dimethylphthalate	nd	nd	
2,4-Dinitrophenol	nd	nd	
4-Nitrophenol	nd	nd	
Diethylphthalate	nd	nd	
Fluorene	0.010	nd	
Phenanthrane	0.013	nd	
Anthracene	nd	nd	
Di-n-butyl Phthalate	nd	nd	
Fluoranthene	nd	nd	
Pyrene	nd	nd	
Butyl Benzyl Phthalate	nd	nd	
Benzo (a) anthracene	nd	nd	
Chrysene	nd	nd	
bis (2-Ethylhexy) phthalate	nd	nd	
Di-n-octylphthalate	nd	nd	
Benzo (b) fluoranthene	nd	nd	
Benzo (k) fluoranthene	nd	nd	
Dimethylbenz (a) anthracene	nd	nd	
Benzo (a) pyrene	nd	nd	
Indeno (1,2,3-cd) pyrene	nd	nd	
Dibenz (a,h) anthracene	nd	nd	
Benzo (g,n,i) perylene	nd	nd	
Methyl Chrysene	nd	nd	
Dibenz (a,h) Acridine	nd	nd	

(a) Data from December 1991
nd= not detected at or below Practical Quantitation Limit (PQL)

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TABLE 3-6
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
WELLS 45 AND 17
PAGE TWO

PARAMETER	WELL 45(a)	WELL 17(a)	DRINKING WATER MAXIMUM CONTAMINANT LEVELS, mg/l
Metals	mg/l	mg/l	
As-Arsenic	nd	nd	0.05
Ba-Barium	0.15	0.04	1
Be-Beryllium	nd	nd	
Cd-Cadmium	nd	0.0024	0.01
Co-Cobalt	nd	nd	
Cr-Chromium	nd	nd	0.05
Cu-Copper	nd	nd	
Mg-Mercury	nd	0.0004	0.002
Ni-Nickel	nd	nd	
Pb-Lead	0.001	0.001	0.05
Sb-Antimony	nd	nd	
Se-Selenium	nd	nd	0.01
V-Vanadium	nd	nd	
Z-Zinc	0.02	0.04	

(a) Data from December 1991
nd= not detected at or below Practical Quantitation Limit (PQL)